Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

A 984 M
168 Rev '51

UNITED STATES DEPARTMENT OF AGRICULTURE
MISCELLANEOUS PUBLICATION No. 168

Washington, D. C.

Issued November 1933
Revised November 1951

MARKET DISEASES OF FRUITS AND VEGETABLES

APPLES, PEARS, QUINCES

By

DEAN H. ROSE
Formerly Senior Physiologist

L. P. McCOLLOCH
Associate Pathologist

and

D. F. FISHER
Formerly Principal Horticulturist

Division of Handling, Transportation, and Storage of Horticultural Crops
Bureau of Plant Industry, Soils, and Agricultural Engineering
Agricultural Research Administration

U. S. DEPARTMENT OF AGRICULTURE
LIBRARY
BELTSVILLE BRANCH

For sale by the Superintendent of Documents, Washington 25, D. C. - - - - - - - - Price 55 cents

UNITED STATES DEPARTMENT OF AGRICULTURE

MISCELLANEOUS PUBLICATION No. 168

WASHINGTON, D. C.

Issued November 1933
Revised November 1951

MARKET DISEASES OF FRUITS AND VEGETABLES: APPLES, PEARS, QUINCES [1]

By DEAN H. ROSE, formerly *senior physiologist*, L. P. MCCOLLOCH, *associate pathologist*, and D. F. FISHER, formerly *principal horticulturist, Division of Handling, Transportation, and Storage of Horticultural Crops, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration*

---

[1] This publication is a revision of the third in a series called "Market Diseases of Fruits and Vegetables." The series is designed to aid in the recognition and identification of pathological conditions of economic importance affecting fruits and vegetables in the channels of marketing, in order to facilitate the market inspection of these food products and to prevent losses from such conditions. The Latin names of causal fungi and the authorities therefor are in accordance with the International Rules of Botanical Nomenclature. The names of the insects mentioned are those approved for general use by the American Association of Economic Entomologists *(91)*.

The statements regarding fruit injuries caused by insects are made with the approval of the Bureau of Entomology and Plant Quarantine. B. A. Porter, of that Bureau, collaborated with the authors in the preparation of the entomological portions of the bulletin.

Most of the colored plates are reproduced from color photographs taken by Lillian A. Guernsey, of the Bureau of Plant Industry, Soils, and Agricultural Engineering. Some reproductions are from water-color paintings made by the late L. C. C. Krieger and the late R. C. Steadman, formerly of this Bureau, and from colored photographs prepared through the collaboration of Webster Bros., Chicago, Ill. The color photograph of internal cork (pl. 4, *F*) was furnished through the courtesy of A. B. Burrell, Department of Plant Pathology, Cornell University.

The plates are arranged so that the diseases and injuries of each kind of fruit are shown as far as possible in the order of their occurrence—in the orchard, during washing, packing, storage, and transit, and on the market. Occasionally similar diseases or injuries that occur at other stages in the sequence of development are included for comparison.

The original (1933) version of this publication was prepared by Dean H. Rose, Charles Brooks, the late D. F. Fisher, and the late C. O. Bratley, all formerly of this Bureau.

CONTENTS

	Page
Introduction	3
Care during and after harvest	3
Effect of removing spray residue	7
Common names of diseases	7
Apples	7
Alternaria rot	7
Ammonia injury	9
Apple maggot injury	9
Apple-cedar and quince rusts	10
Bitter pit	11
Bitter rot	13
Black rot	14
Blotch	15
Blue mold rot	16
Box-wood scald	18
Brown core and internal browning	18
Brown rot	20
Bruises	21
Bull's-eye rot	22
Chemical injuries	23
Codling moth injury	26
Core rot	27
Cork (boron-deficiency cork)	27
Drought spot	29
Fisheye rot	29
Flyspeck	30
Freezing injury	30
Fruit spot	34
Gray mold rot	35
Hail injury	36
Heat injury	37
Honeydew and sooty mold	37
Internal break-down	37
Internal browning	38
Jonathan spot	38
King David spot	39
Leafhopper specking	39
Leaf roller and green fruitworm injury	39
Miscellaneous rots	40
Pansy spot	40
Pear leaf blister mite injury	41
Phytophthora rot	41
Pink mold rot	42
Plum curculio injury	42
Powdery mildew	43
Quince rust	44
Red spots	44
Rhizopus rot	44
San Jose scale injury	44
Scab	45
Scald	47
Side rot	48
Skin and flesh cracking	49
Soft scald	51
Soggy break-down	51
Sooty blotch	52
Spongy dry rot	52
Spray injury	53
Stigmonose (insect punctures)	54
Sunburn, sunscald, and delayed sunscald	55
Washing injuries	55
Water core	55
Pears	56
Ammonia injury	56
Black end	57
Black rot	58
Black spot	58
Blue mold rot	58
Brown rot	58
Bruising	58
Bull's-eye rot	58
Core break-down	58
Freezing injury	59
Gray mold rot	59
Pear leaf blister mite injury	60
Pear psylla injury	61
Pink mold rot	61
Powdery mildew	61
Rhizopus rot	61
San Jose scale injury	61
Scab	61
Scald	62
Side rot	62
Silicate injury	63
Sooty blotch	63
Spray injury	63
Stigmonose (insect punctures)	63
Stony pit, corky spot, and boron-deficiency pitting	63
Quinces	65
Black rot	65
Black spot	65
Blue mold rot	65
Brown rot	65
Oriental fruit moth injury	65
Literature cited	66

INTRODUCTION

Pome fruits—apple *(Malus sylvestri* Mill.), pear *(Pyrus communis* L.), and quince *(Cydonia oblonga* Mill.)—must be handled carefully and held under refrigeration until placed on the market if quality is to be maintained and spoilage is to be held to a minimum. According to Wiant and Bratley *(136)* [2] some spoilage occurred in about four-fifths of the carlots of apples inspected at New York City during 1935–42 and in about two-thirds of those of pears.

The word "disease" as used in this publication means any departure from the normal or usual condition of fruits that renders them inedible or otherwise undesirable for use by consumers. Under such a definition, internal break-down of apples is as truly a disease as is blue mold rot or scab. Internal breakdown, however, is a nonparasitic, or physiological, disease produced by environmental factors and the life processes of the fruit itself, whereas scab and blue mold rot are produced by the action of certain fungi that are referred to as the causes of the respective diseases.

Some of the more important facts concerning fungi (molds) should be kept in mind in dealing with fungus diseases of fruits. An important characteristic of most fungi is that they produce minute bodies called spores, which are usually the most important means by which fungi reproduce themselves and are distributed. Being small and light, spores are easily carried by wind, rain, insects, and other agents. Spores of several kinds of fungi that attack fruits are quite common on the soil surface and on all plant parts above ground. Spores on the surface of a fruit, under favorable conditions, produce fine fungus threads that may enter the fruit and cause disease.

Fungus spores lie inert until temperature and moisture conditions are favorable for their germination. The fungus threads they produce may or may not enter the fruit through the unbroken skin, but they are always more likely to enter if skin breaks are present. Factors that favor the development of each disease in storage, in transit, or on the market are discussed under appropriate headings.

Care During and After Harvest

POME FRUITS IN GENERAL

All fruits should be handled carefully through all stages of the harvesting and packing processes. Unlike eggs, apples or pears are not visibly ruined when they are dropped a foot or two. They may sustain bruises or skin breaks, however, that during storage or in transit may mean serious loss. In this connection, it should be remembered that the susceptibility to fungus rots increases as the fruits become more mature, and hence ripe fruits require very careful handling at all stages of the marketing process if excessive loss from rot is to be avoided.

---

[2] Italic numbers in parentheses refer to Literature Cited, p. 66.

It is highly important also that packing houses, their machinery, and their immediate surroundings be kept free of all cut, mashed, or decaying fruits and of all other fruits culled out of the pack for any reason. A few apples or pears affected with blue mold rot or gray mold rot, if run through grading machines or left lying on the floor in out-of-the-way places, can produce enough spores to make them a serious source of danger to all the fruits that pass through the house. Stacks of field boxes filled with rotting culls give off spores to every wind that blows over them. If they stand inside the packing house or even though outside near doorways, they mean trouble. The safest procedure is to get them away from the house as soon as possible and to clean up the grading machinery, the bins, and the packing-house floor at least once every day. It is desirable to have the floor of the house tight, to keep mashed and decaying fruit from dropping through to the ground below and there becoming a source of fungus infection.

When apples, pears, and quinces arrive on the market the job of getting them to the consumer in attractive, edible form is only partly done. From the time they are taken out of a car or truck until they are carried into someone's kitchen they need as much care and attention as was expended on them in a well-managed packing house at the shipping point. However, judging from what can be seen in almost any grocery store or market one can safely say that they do not always receive such care.

A few general recommendations that are applicable to all three kinds of fruits can be made.

The filled packages and the fruit after being unpacked should be handled carefully at all times. This avoids bruising, which makes the fruit unattractive and may lead to decay before the fruit finally reaches the consumer. Bruises are often the most common cause of complaint among retail customers. Blue mold rot is particularly likely to get started at cuts and bruises, and it can develop rapidly at temperatures commonly occurring in the receivers' storerooms or in grocery stores and markets. Slamming packages into place in a stack, a truck, or a store is decidedly bad practice. So also is walking on top of packages.

Fruit should be protected from summer temperatures by keeping it in the shade whenever possible. Placing it in a show window where it gets full sun for part of the day is a sure way to hasten overripeness and decay.

If a carload of fruit showing signs of freezing arrives on the market, there are several possible ways in which it may be handled, although the receiver may not always be free to choose the one he will use. In many instances he can do nothing but unload the fruit and put it into trade channels. On the other hand, he may be able to leave it in the car to thaw out naturally because of moderate outside temperatures or he may raise the car temperature by placing heaters in the car when the outside temperature remains below 32° F. If heaters are used they should be operated to produce moderate heat. As a third choice, he may unload the fruit and take it to a warehouse or store and leave it to thaw slowly.

A temperature of about 40° F. has been found most satisfactory for the thawing of apples and is desirable for most other fruits. Too high temperature—60° to 70°, for example—favors discoloration, break-down, and decay. If packages have to be handled in order to put them in a place where the fruit will thaw, they should be stacked in a way that permits free circulation of air around them.

Whatever method is used in caring for a shipment, it should always be remembered that fruit should not be handled while frozen if such handling can possibly be avoided; the reason for this is that when fruits are frozen the effect of even slight bruising extends deep into the flesh and much more damage results than from similar bruising of unfrozen fruits.

If fruits have to be hauled to a pier, warehouse, or store in freezing weather, they should be protected by means of paper, hay, or straw around the inside of the truck body and tarpaulins over the top. Individual packages in small lots, if hauled to stores in unheated trucks in freezing weather, can be protected by wrapping them in heavy paper.

If the shipments arrive at market in good condition but, after being unloaded, have to be held on a pier or in a receiver's warehouse or storeroom during severely cold weather, the danger that they may freeze depends on (1) the quantity of the fruit held and its temperature at the time of unloading, (2) the amount of artificial heat provided, (3) the tightness and insulating quality of the pier or warehouse construction, (4) the temperature of the storage space during the previous day, and (5) the quantity of other commodities held in the storage space and their capacity for retaining heat.

Additional facts that should be kept in mind in trying to prevent freezing are (1) fruits cool more slowly if packed tightly than if packed loosely and more slowly in tight boxes or baskets than in slatted crates; (2) fruits cool more slowly if wrapped than if not wrapped; (3) close stacking of packages gives some protection from freezing; (4) the bottoms of outside stacks need the most protection, because freezing occurs there first; (5) sawdust along the bottoms of outside doors helps to keep cold air out; (6) a covering, such as a tarpaulin, over the stacks and tucked carefully around them, especially at the bottom, helps to retain both the heat already present in the fruit and that which it produces by virtue of its being alive (heat of respiration).

Even if there is no permanent equipment for heating the room or pier, substantial help in keeping up the air temperature can be obtained by setting barrels, oil drums, or buckets of hot water under the tarpaulins where heat is most likely to be needed. Since water will freeze before any of the fruits or vegetables do, the heat it gives up on freezing is available for further protection. The heat that could be furnished by a lighted lantern, an oil heater, or a container full of hot water set under a tarpaulin covering stacks of produce might seem small, but it might be just enough to keep the fruit from freezing. Further information on freezing injury is given in Circular 713 *(118)*.

The chemicals mentioned in the treatments are poisonous to man and animals when taken internally. Some of them also cause a rash if they come in contact with the human skin. Therefore care should be taken in handling and storing them and in disposing of any unused solution or unused chemical.

APPLES

Next to bad bruising, overripeness is the condition in apples which retail consumers object to most. How often is heard the criticism: "Nice-looking large red apples, but mealy and tasteless." That always means overripe apples. How fast do apples get overripe? The answer depends on the temperature—in a retailer's store as well as in commercial storage or in the hands of the grower after harvest. Apples ripen about twice as fast at 70° as at 50° F., twice as fast at 50° as at 40°, and twice as fast at 40° as at 32°. If they are ripe when bought for resale, some kinds (Delicious in particular) can become overripe and mealy in 2 or 3 days at ordinary store temperatures and in even less time if they are piled behind windows for display and are not protected against hot sunshine. The safest procedure for a retail merchant is to regard apples from cold storage late in the season as being highly perishable and to move the apples into consumers' hands before they become overripe and out of condition.

Retailers often buy apples in larger lots than they can dispose of before the fruit gets overripe. Unless refrigeration facilities can be utilized, the merchant who would sell only apples in prime condition should obtain fresh stock from cold storage at intervals of not over 2 or 3 days rather than hold a surplus at warm temperatures. Some stores have a special walk-in refrigerator for fruits and vegetables. Unless such refrigeration is available the retailer should purchase fruit often and in relatively small quantities and hold it in a cool, well-ventilated place, such as a stockroom where screened or barred windows can be left open, or in a cool basement. He should avoid stacking fruit against outside walls and thus reduce freezing hazard in winter and heating in spring.

Packed boxes should always be stacked on the side, never on the top, which is bulged to hold the fruit in place. Only when the top is removed, and pressure is thus released, is it safe to let the boxes rest on the bottom. Bushel baskets should be staggered by placing one basket on the edges of two others, to keep all pressure away from the center of the lids.

In displays, apples should be kept away from potatoes, onions, and other crops from which they might absorb odors. It is preferable to keep the stock in the original containers until needed for display. Displays should not be set up near radiators, stoves, or sunny windows. They should be of such a size that normal sales would necessitate replenishing them with fresh stock several times a day.

(See *43, 67, 85, 87, 119.*)

PEARS

The recommendations just made for the care of apples on the market apply equally well to pears. Careful handling is especially important for pears, because when in prime eating condition they

are really a soft fruit and much more susceptible to injury by bruising than most varieties of apples. Most varieties of pears need a special ripening temperature of 60° to 70° F., preferably about 65°, after removal from storage. If Bosc, Flemish Beauty, and Comice pears are held in cold storage beyond their season, they do not ripen satisfactorily when placed at 65° and may not ripen at all.

It should also be remembered that pears ripen poorly at temperatures much above 70° F. The poor quality that Bartlett pears sometimes have on the market may result from the fact that they arrive at consuming centers in summer weather, when the temperatures to which they are exposed in grocery stores and markets and on fruit stands are too high for proper ripening.

(See *83, 103.*)

QUINCES

No recommendations are necessary for quinces beyond those already made for pome fruits in general.

Effect of Removing Spray Residue

At various places in the publication, descriptions are given of injuries that may result from washing apples or pears to remove spray residues. It cannot be emphasized too often, however, that if the washing is done with proper equipment and care and under desirable sanitary conditions neither the market value nor the keeping quality of the fruit will be impaired.

Common Names of Diseases

The common names of diseases used herein are for the most part those that have become well established in publications on plant diseases and that are in general use among persons concerned with the growing and marketing of apples, pears, and quinces. A few, such as Jonathan spot and York spot, include the name of the variety on which they were first described or on which they are most common. Some of the names such as bull's-eye rot, flyspeck, and scald are briefly descriptive of the diseases to which they are applied. Still others contain the name of the causal or inducing agent; among these are alternaria rot and freezing injury.

A few of the names imply a quality of the affected tissues which is not really characteristic or typical, but they are so well established by usage that it has seemed best to retain them. The diseased flesh of apples affected with bitter rot and bitter pit is not always bitter; black rot lesions are often only dark brown, and brown rot lesions eventually become black.

Most of the insect injuries are named for the insects that cause them.

APPLES

Alternaria Rot

(*Alternaria tenuis* auct.)

CAUSE, OCCURRENCE, AND SYMPTOMS

Alternaria rot of apple is caused by the fungus *Alternaria tenuis*. In nature the organism grows on apple leaf tissue killed by various agents as well as on other dead or dying plant ma-

terials. Being abundant in the orchard, the spores are present on the fruit when it is harvested. *A. tenuis* is a weak parasite, which does not cause decay unless the apples have been injured or weakened. It has been observed growing and producing spores on the calyx sepals of apples without causing rot.

Under favorable conditions the rot may occur on apples from all producing sections. During the long period of storage the rot develops proportionately with the type of injury permitting its entry and with the vitality of the apple. Where the injury is slight and the apple firm alternaria rot is characterized by small, firm, slightly sunken lesions, which may be brown around the edges but are covered for the most part by a rough, black crust. When apples are removed from storage these spots may enlarge and produce larger rotted areas, which may be brown or grayish.

Alternaria rot often develops by midseason in cold storage on apples showing injuries such as delayed sunscald (pl. 5, *F*), bruising, or chemical injury. In apples held late in storage the rot may develop at skin checks, as in the York Imperial variety, or even at enlarged, ruptured lenticels over bruises.

The rot lesions are more or less round, and when less than 1 inch in diameter they resemble side rot in color and appearance (pl. 5, *E*). They are, however, firm, with fairly tough skin, whereas tissue affected with side rot gives readily under pressure and the skin is tender. The spots are brown when small, but generally become black as they develop.

Alternaria infections frequently follow the death of the skin and tissue as a result of scald, soft scald, or Jonathan spot. The lesions are usually black, not sunken, and often without definite margins. A similar rot is produced by *Cladosporium herbarum* Fr., a very weak parasite, on killed apple tissue. It is inadvisable to attempt to distinguish the two without laboratory study. The most practical procedure is to describe the condition as a secondary, undetermined black rot following scald, soft scald, or other diseases as the case may be.

Certain other rots may be confused with alternaria rot, but they can usually be differentiated by careful examination. Black rot is distinguished from alternaria rot by the presence of either alternating zones of light and dark brown or black pimplelike fruiting bodies (pycnidia). Brown rot is usually not sunken, may have black spots at the lenticels and, when it becomes uniformly black, has a velvety sheen. Bitter rot can be differentiated from alternaria rot by its brown color and sometimes by the presence of wet pink or cream-colored spore masses, which may be in concentric rings.

Alternaria rot does not spread from one fruit to another by contact either in storage or in transit.

CONTROL MEASURES

Control of alternaria rot depends upon careful handling during picking, washing, and packing and on the prevention of physiological diseases and injuries which open the way for infection. Prompt storage and cooling of the fruit are of primary importance. Removal of apples from cold storage to warmer temperatures favors the development of the rot. Consequently moving

apples rapidly from the merchant to the consumer and keeping them as cool as possible help in preventing spoilage.

(See *11, 12, 59, 114.)*

Ammonia Injury

(See Pears, Ammonia Injury, p. 56; pl. 5, *C.*)

Apple Maggot Injury

(*Rhagoletis pomonella* (Walsh))

occurrence, symptoms, and effects

The injury caused by the apple maggot, which is often found in apples grown in the northeastern part of the United States, consists in small tunnels winding through the flesh. There may be little or no external evidence of infestation. Affected fruits are likely to be misshapen. Most of the damage is done on sweet or subacid varieties of summer and fall apples, but winter varieties do not entirely escape.

The maggots have been found to distribute through the interior of the fruits bacteria and molds, which cause the flesh to rot and break down and make badly infested fruits of the early varieties drop prematurely. In the fruits of winter varieties which fail to drop, the maggots are usually killed by the pressure of the rapidly growing tissues; the tunnels remain as brown woody streaks through the flesh (pl. 15, *A*) and make the fruit less suitable for eating raw or cooking. A small amount of injury results from the egg laying of the flies. The flesh immediately surrounding the egg punctures sometimes fails to grow, and therefore there are dimplelike depressions in the surface.

cause

The apple maggot, or railroad worm, is a footless white or cream-colored larva, usually about ⅓ inch long when full-grown. The adult form is a fly, somewhat smaller than a housefly, which emerges from the soil during late June, July, or early August, depending on the locality. The flies make tiny punctures in the skin of the fruit and place their eggs just underneath. The eggs have a short period of incubation; in hot weather they hatch in 4 to 6 days. The period spent by the maggot in the fruit varies greatly but may be as short as 2 weeks. When mature, the maggots leave the fruits, which by this time have fallen to the ground, enter the soil, and form puparia which resemble grains of wheat. Within the puparia the insects transform to the adult stage. They emerge the following summer or sometimes the second summer.

control measures

Satisfactory control of the insect has been obtained by spraying the trees with lead arsenate at the proper time in the summer, thus killing the adults before they lay their eggs. Usually two applications of lead arsenate at a strength of 2 pounds in 100 gallons of water, with an interval of approximately 2 weeks between, have been sufficient. This program is likely to result in enough residue to require removal. In recent years workers in New York State have obtained satisfactory control of apple

maggot by the use of DDT. Current recommendations of the Bureau of Entomology and Plant Quarantine or of State agricultural experiment stations should be used as a guide in working out a control program for this pest.

Experiments carried on by the New York State Agricultural Experiment Station have shown that if infested fruit is held continuously at 32° F. for 40 days all eggs and maggots are killed. This treatment may be used in meeting quarantine requirements relative to the shipment of infested fruit.

(See *2, 24, 47, 48, 101.)*

Apple-Cedar and Quince Rusts

(*Gymnosporangium juniperi-virginianae* Schw.)

Apple-cedar rust occurs in practically all apple-growing sections of the central and eastern United States. Diseased fruits are only occasionally found on the market and even then the rust is merely a slight blemish, since badly marked fruits are usually culled out before shipment. The varieties most often affected are York Imperial, Wealthy, Jonathan, Ben Davis, and Rome Beauty. The rust fungus belongs to a large group of fungi that must complete the different stages of their life cycle on different hosts. The most common second, or alternate, host of apple-cedar rust is red cedar (*Juniperus virginiana* L.), on which the fungus produces the familiar rough, brownish galls known as cedar apples. From these it spreads in the spring to apple leaves and young fruits, but it must pass again to a red cedar if it is to continue its development.

Infection with the rust fungus takes place when the fruits are young. It either causes the fruits to drop while still undeveloped or stunts their development. They often become noticeably flattened or otherwise malformed.

Rust usually appears on the calyx end of an apple as grayish-yellow to yellow spots (pl. 2, *A*)[3] that vary in superficial diameter from about ⅛ to ¾ inch and extend into the flesh for ¼ to ½ inch or even to the core. The surface of the spots may be smooth, or it may be roughened with the spore-producing bodies (aecia) of the fungus, which are in the form of pimples or of open, cup-shaped receptacles with flaring, papery edges. None of these measure more than 1/16 inch in diameter. The flesh beneath rust spots is woody and usually greenish, though in the Winesap and the Ben Davis the green is sometimes intermixed with a pronounced brown.

The disease can be controlled by spraying or by removing all red cedars in the neighborhood of an orchard. The spray schedule followed should be that recommended by the local agricultural experiment station. It has been found necessary to eradicate cedars to a distance of 1½ to 2 miles from an orchard for satisfactory control without spraying.

(See *57, 65, 88, 114, 129.)*

Quince rust *(Gymnosporangium clavipes* Cke. & Pk.) produces swellings rather than galls on red cedar. It has been known to

[3] Fruit shown in plate 2, *A*, is affected also with scald, which appeared after fruit was removed from storage.

attack Delicious, McIntosh, Winesap, and Yellow Transparent apples, producing dwarfing, distortion, and an internal condition which affects more of the fruit tissue than apple-cedar rust does. Aecia are not usually produced. Only occasionally do affected fruits reach the market. The affected surface tissue is deeper green than the normal skin color (pl. 2, *B*) instead of yellow like that affected with apple-cedar rust.

(See *88.*)

Bitter Pit

Bitter pit occurs in all the important apple-growing regions of the world. In the United States it may be found on practically all varieties of apples, but it is not of commercial importance on all. Baldwin, Northern Spy, Rhode Island Greening, Grimes Golden, Tompkins King, Yellow Newtown, York Imperial, Rome Beauty, Winter Banana, Stayman, Arkansas (Mammoth Black Twig), Arkansas Black, Delicious, and Gravenstein are among the more susceptible varieties.

In its usual form the disease is characterized by sunken spots, about $\frac{1}{16}$ to $\frac{1}{8}$ inch in diameter, distributed over the calyx half of the apple. The spots resemble small bruises and are sometimes wrongly ascribed to hail injury. In the early stages they have a water-soaked appearance, but later they become more highly colored than the surrounding fruit surfaces, taking on a deep-red color on blush areas and remaining bright green on green or yellow surfaces. They finally become brown, gray, or sometimes black and are somewhat sunken (pl. 4, *A*). When the apple is peeled or cut, numerous spots and streaks of brown spongy tissue become evident just beneath the skin (pl. 4, *B*). Bitter pit spots, though closely associated with the terminal branches of the vascular bundles, or food- and water-conducting system, of the apple, are not confined to the region immediately beneath the skin, but may occur deep in the flesh. The affected tissue often has a bitter taste.

On apples of the Yellow Newtown variety the spots may be more prevalent on the cheek than on the blossom end and are usually rather sharply sunken. In addition, they are more nearly circular in outline than those of the common form just described. The skin covering the depressed areas usually varies in color from gray to dark brown or black. Occasionally such spots have a more or less complete border of blackened skin that is only slightly depressed, if at all, below the level of the healthy skin.

Bitter pit spots on the Winter Banana are frequently large and sharply sunken, and in such cases they have the appearance of having been formed by the coalescence of several smaller spots; sometimes they comprise areas $\frac{1}{2}$ to 1 inch long and of varying width.

A condition on York Imperial apples in the Shenandoah-Potomac valley districts known as York spot is here considered to be a form of bitter pit. It develops while the fruits are on the trees and results in an appearance different from that of the usual bitter pit on other varieties. While York spot is not definitely known to be bitter pit, there seems to be good evidence that it is; namely, it is induced by the same conditions in the orchard

that cause bitter pit. The disease at harvesttime is characterized by small to medium-sized surface depressions, or there may be a general corrugation of the surface of the fruit (pl. 4, *C*). Corky spots occur in the flesh immediately below the surface depressions and sometimes also at some depth in the flesh (pl. 4, *D*). The York Imperial is not subject to boron-deficiency cork, a fact which eliminates the need for comparing York spot with cork.

The presence of high concentrations of certain salts in irrigation water is sometimes associated with and seems to be the cause of a condition in apple fruits that can hardly be distinguished from bitter pit. In the Pacific Northwest instances have been known of spotting following the use of irrigation water containing a high percentage of epsom salt (magnesium sulfate).

Bitter pit can be distinguished from fruit spot by the characteristics mentioned on page 35. When confined to the surface region, bitter pit is hard to distinguish from some forms of stigmonose, except for the facts that the individual corky areas associated with stigmonose are often larger than most bitter pit spots and minute punctures can sometimes be seen in the skin that covers them.

Bitter pit is a nonparasitic, or physiological, disease, and its occurrence is largely determined by orchard conditions. It is worse on fruit from young trees, especially if the crop is light, than on fruit from older trees, worse on large apples than on small ones, and worse on apples picked when immature than on those picked when mature. In dealing with susceptible varieties, growers could probably avoid losses and costly repacking by segregating light-crop fruit and disposing of it to processing plants.

Bitter pit is greatly increased by heavy irrigation and heavy rainfall, particularly when these occur late in the growing season, and by heavy nitrogen fertilization. Conversely, everything that contributes to the stabilizing of moisture conditions in the soil and to even, normal growth of the fruit throughout the season is of value in preventing the disease.

Investigators in the United States and Australia have obtained evidence that the disease is due to the killing of immature, starch-filled tissues of rapidly growing apples or of fruit in storage, probably resulting from excessive transpiration that induces osmotic action between the starch-filled cells and those in which most, possibly all, of the starch has been changed to sugar. According to this explanation, the starchy areas are killed by excessive desiccation. It should, therefore, be possible to reduce the amount of bitter pit by speeding up the rate of ripening. Bitter pit develops more rapidly at 50° F. than at 32° and more rapidly at both these temperatures than at 70°. Considerable bitter pit may develop within 7 to 10 days on susceptible varieties at 50°. In some of the susceptible fruit, however, bitter pit will not have developed by the end of that time. Bitter pit often develops in a month or 6 weeks at cold-storage temperature, and develops further, especially on immature fruit, after removal from such storage.

Bitter pit may begin to appear before the apples are harvested, but the disease is seldom fully manifested at that time. Susceptible

fruit, especially that of early-maturing varieties, can be expected to develop bitter pit during the transit and marketing period immediately after harvest. The disease does not spread from one fruit to another, but pits may enlarge and new pits may develop during transit on apples removed from cold storage.

(See *1, 12, 13, 21, 22, 31, 43, 59, 61, 62, 65, 79, 95, 99, 100, 113, 114, 124, 136.)*

Bitter Rot

(*Glomerella cingulata* (Ston.) Spauld. & Schrenk)

OCCURRENCE AND SYMPTOMS

Bitter rot is principally a disease of apple, though it may occur on pear, peach, quince, and cherry. It may occur in practically all apple-growing sections east of the Great Plains, but it typically occurs in hot, humid districts. It is most common and most destructive from Arkansas and southern Missouri eastward to Virginia and farther south. Even there it is irregular in occurrence, being worse in warm, wet growing seasons.

The disease usually appears in the orchard in late June or early July. It becomes most serious on well-developed fruit in August and September; hence the name "ripe rot" is sometimes applied to it. Susceptible varieties include Yellow Newtown, Delicious, Golden Delicious, Yellow Transparent, Jonathan, Winesap, and Ben Davis.

Bitter rot is characterized by brown, definitely limited spots varying in size from mere specks to lesions involving the whole side of an apple. Rots developed in the orchard about harvesttime are not sunken at first and are generally marked by narrow, concentric zones of light and brown color. Eventually the spots become sunken, but they remain relatively firm. Spots ½ inch in diameter or larger usually show spore masses that may or may not be arranged in concentric circles. Under orchard conditions these spore masses are at first pink or cream-colored; eventually they become gray or almost black (pl. 6, *A*).

Bitter rot is sometimes found on apples in storage and during the period of marketing after the fruit is removed from storage. Slight infections existing when the fruit is stored continue to enlarge in storage until the fruit temperature reaches 50° F. Rot development is arrested then; but the fungus remains alive and, when the apples are removed from storage, the rotted areas enlarge. The decayed spots in storage are usually small, ranging from ¼ to ⅝ inch in diameter. They are flat or slightly sunken, firm, and of a uniform, medium-brown color. Rotten spots found after the fruit has been removed from storage are usually larger and more sunken and often produce wet pink or cream-colored spore masses (pl. 6, *B*). The more or less concentric arrangement of the spore masses distinguishes the disease from black rot, in which the spore-producing bodies *(pycnidia)* are always black and scattered irregularly over the diseased area.

CAUSAL FACTORS

The disease is spread by means of spores, which are produced in immense numbers during the growing season on bitter rot mummies of the preceding year or on cankers caused by the fire blight

organism, the black rot fungus, and other agents, at the edges of which the bitter rot fungus has established itself. Infection may occur in warm, wet weather when the spores are washed down on the apples.

CONTROL MEASURES

Control measures include removal of bitter rot mummies and repeated spray applications according to the schedule recommended by the local agricultural experiment station. When bitter rot is present at harvest careful sorting and prompt storage and cooling help to hold the rot to a minimum in the pack. Apparently it does not spread from one fruit to another.

(See *12, 59, 65, 111, 113, 114, 122.)*

Black Rot

(*Physalospora obtusa* (Schw.) Cooke [4])

OCCURRENCE AND SYMPTOMS

Black rot is a disease of apple, pear, and quince that is found in most of the producing sections of the United States east of the Rocky Mountains. Practically all varieties of pome fruits are susceptible, but the greatest losses usually occur on early-maturing varieties.

Black rot is characterized in its early stages by brown rotten spots on any part of the apple (pl. 5, *G*). These spots vary greatly in size and are usually irregular in outline. Under orchard conditions they may show zones of different shades of brown; for that reason the disease is sometimes called ring rot. In late stages the spots enlarge, become dark brown to black, and sometimes show numerous small black pimples (pycnidia) scattered irregularly over the surface. In these pimples are produced the spores, the chief means by which the fungus is distributed and propagated. Apple flesh affected with black rot is usually quite firm. Where infection occurs in fruit held at ordinary temperatures after removal from storage, the flesh may become soft and mushy.

CAUSAL FACTORS

Black rot is caused by the fungus *Physalospora obtusa,* which has two spore stages, both capable of producing the disease. The fungus attacks the leaves and the wood, as well as the fruit.

Under favorable temperature conditions, 50° F. or higher, rotting of the fruit takes place in the orchard, in transit, in storage, and on the market. Black rot does not ordinarily spread from one fruit to another.

Infection may occur at injured places in the skin such as worm holes, bruises, limb rubs, hail injuries, and rain cracks. The rot develops freely if conditions are favorable and may finally involve the whole fruit. Infection may also follow spray or frost injury at the blossom end, producing what is known as blossom-end rot. The rot may develop steadily from the time of infection and finally involve the whole apple; or it may progress for a short time, then become quiescent, and start up again when conditions become more favorable—for example, when the fruit is shipped

[4] Syn., *Physalospora cydoniae* auct. Am. and *P. malorum* (Pk.) Shear.

to market without refrigeration. Black rot extends into the fruit very rapidly, often reaching the core when the rotten spot on the surface is only 1 or 2 inches across.

CONTROL MEASURES

The sprays applied for the control of apple scab will usually prevent the leaf spot phase of the disease. Control of black rot on the fruit depends primarily on elimination of deadwood through proper pruning. Prevention of insect and mechanical injuries to the fruit and maintenance of temperatures in storage and in transit that are unfavorable to the growth of the fungus aid in reducing decay.

(See *11, 12, 59, 64, 65, 114, 128, 143.*)

Blotch

(*Phyllosticta solitaria* Ell. & Ev.)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Blotch occurs in the territory extending west from southern New York to southern Iowa and South Dakota and south to Georgia and Texas. It is most apt to be destructive in Kansas, Arkansas, and the southern parts of Missouri, Indiana, Illinois, and Ohio. The disease occurs in varying degrees of severity on McIntosh, Maiden Blush, Northwestern Greening, Rome Beauty, Yellow Newtown, and Yellow Transparent. It is rarely seen on Delicious, Grimes Golden, Jonathan, Stayman, and York Imperial.

Blotch spots on the fruit are characteristically fan-shaped areas with fringed margins grouped around a common center, the diameter of the spots varying from ¼ to ½ inch or even more (pl. 1, *E*). The spots are light brown and superficial at first, but later they become nearly black and markedly sunken. The small black fruiting bodies (pycnidia) begin to appear within a few days after a blotch spot becomes visible. Toward harvesttime cracks occur in the older spots and render the fruit worthless.

Most of the fruit infections occur before the end of June, the particular time varying somewhat with the variety and with the weather during the growing season. Much of the badly diseased fruit drops before picking time. That which arrives on the market suffers seriously from the disfiguring effect of the blotch spots and occasionally also from rots resulting from secondary fungus infection. Blue mold and the black rot fungus are most commonly found associated with blotch in this way.

CAUSAL FACTORS

Blotch is caused by the fungus *Phyllosticta solitaria,* which attacks the leaves, fruit spurs, and twigs of the apple. From the last two infection spreads in the spring to other parts of the tree.

CONTROL MEASURES

In orchards where the disease has been destructive, blotch can be controlled by spraying three times at 3-week intervals, beginning about 3 weeks after the petals fall. The recommendations of the local agricultural experiment station regarding materials to be used should be followed.

(See *12, 59, 65, 112, 114.*)

Blue Mold Rot

(*Penicillium expansum* Thom)

OCCURRENCE AND SYMPTOMS

Blue mold rot is the most common and usually the most destructive of all the rots found on apple, pear, and quince in transit, in storage, and on the market. It occurs on all varieties of these fruits grown in all parts of the country.

The rot appears as soft, watery spots. The decayed portions are sharply separated from the healthy tissue. If the margin of the rot is rubbed lightly, a sharp margin of healthy flesh can readily be detected. The spots range in color from brown to pale straw and show all possible variations in size (pl. 6, *C–E*). They may occur on any part of the fruit. The spots are shallow at first, but they extend deeper very rapidly—in fact, just about as rapidly as they increase in diameter on the surface—so that by the time the rot reaches the core it has involved a third or more of the fruit. Internally the decayed tissue is watery and has a glassy appearance. It can readily be scooped out from the healthy tissue. Whether a surface growth of blue mold develops depends very largely on temperature and moisture conditions and very little on the size of the spot. In dry, cool air surface mold rarely appears, even when the fruit is totally decayed. In air that is moist and warm surface mold is almost sure to appear on spots of any size. Usually small spore-bearing fungus tufts appear on the surface. These are white at first and bluish green later. The blue-green color is due to the spores. In all the pome fruits a musty odor can be detected when the rot becomes well advanced and spore production is heavy. The decayed flesh also has a musty taste.

CAUSAL FACTORS

Blue mold *(Penicillium expansum)* sometimes produces a superficial growth even where it is not causing rot. Where rot exists the fungus can be found in the rotted tissues, even in the smallest spots; later the fungus may become evident externally in the form and color already described.

Blue mold rot is not important as an orchard disease. Under conditions of abundant rainfall and summer or early-fall temperatures it may occur on fruits fallen to the ground or on mashed or overripe ones around the packing house, where it becomes important as a source of infection. It is almost never found on fruits hanging on the tree unless they have been injured by insects, hail, or other agents that produce skin breaks.

Despite careful handling methods and packing-house sanitation, most if not all of the fruit carries blue mold spores on its surface when it is packed. If conditions in storage or transit are favorable, this spore load can eventually give rise to fruit decay.

In the past blue mold was generally regarded as a wound parasite. It was shown in 1932 *(5)*, however, that blue mold can penetrate uninjured apples through lenticels, such infection having been observed on eight varieties of apple. More recent investigations in the Pacific Northwest *(37)* confirmed the fact that the fungus can enter apples through open lenticels. These investiga-

tions showed a relation of washing injury and abundance of spores to subsequent decay. It is now recognized that blue mold may enter apples through mechanical injuries, such as cuts by basket rims and stem punctures, through open lenticels, and through lesions in the skin caused by severe washing treatment. Late in the storage season, when the fruit has become weakened by ripening and aging, most varieties have been found very susceptible to lenticel infection by blue mold. This type of lenticel infection may readily result when rotten apples are handled carelessly during repacking late in the storage season.

Factors that favor the development and spread of blue mold rot may be classed as follows: (1) The extent of the spore load on the fruit, (2) the condition of the fruit, and (3) environmental conditions. The relation between spore load and the amount of blue mold decay has been clearly demonstrated by dipping fruits in a spore suspension prior to storing and comparing the extent of decay with that on fruits carrying only the natural spore load. The presence of open lenticels, mechanical injuries, including bruises, and washing injuries (both skin cracks and injuries beneath open lenticels), along with aging of the fruit, has an important effect on susceptibility. Environmental conditions such as moisture, ventilation, and temperature directly influence the development of decay. The atmospheric moisture necessary to prevent apples from shriveling is sufficient for blue mold development. Lack of ventilation due to tight packing and to lack of air space in stowing increases the moisture about the fruit and slows down the rate of cooling, making conditions unusually favorable for rot development.

Blue mold develops more rapidly at temperatures higher than the usual storage temperature for apples (30° to 32° F.). Apples that are delayed in going into storage, cooled slowly in storage, stored until late in the season, or held at warm temperatures after removal from storage are particularly subject to infection. The disease is not necessarily prevented or arrested even at 30° to 32°. Rotten spots continue to enlarge, and new infections are initiated at these temperatures. Slow progress in decay is made in the early part of the storage season when the apples are firm and resistant, but in the long months of storage blue mold develops and causes the most serious losses to stored apples. Apples wounded by small pin punctures and inoculated by a spore-suspension dip developed small but visible lesions in 30 days at 31° to 32°. By the end of 60 days such lesions had enlarged to ¾ to 1 inch in diameter.

CONTROL MEASURES

Some of the more important means of controlling blue mold rot are careful handling, packing-house sanitation, avoiding chemical injury in the washing process, and prompt cooling to cold-storage temperatures. Reduction of the spore load carried by the fruit is of great importance. This may best be accomplished by rigid packing-house sanitation.

Sodium chloro-2-phenylphenate is being used as a disinfecting wash in certain producing districts of the Northwest. (See Pears, Gray Mold Rot, p. 59.) Blue mold rot has been reduced by this

treatment, but disinfection does not replace sanitation, careful handling, and prompt cooling.

Delay in cooling shipments caused by slow loading, belated icing of the cars, or loading of warm fruit gives an opportunity for the rot to develop and so increases the probability of loss. Delay in moving the cars also increases this probability by giving the fungus a longer time in which to work.

(See *5, 6, 12, 37, 43, 58, 59, 60, 65, 114, 133, 136.)*

Box-Wood Scald

In 1928 Fisher *(39)* reported injury on apples from contact with boxes made of heartwood Douglas-fir *(Pseudotsuga taxifolia* (Poir.) Britton). The injury occurred when the wood and fruit were wet. Box-wood injury has not been observed in recent years. It is possible that changes in the spray program are responsible for the absence of injury, but this has not been established.

(See *39.)*

Brown Core and Internal Browning

Brown core and internal browning are nonparasitic diseases, heretofore described separately, that appear to have a common cause. It is suspected that they are the same disease differently manifested in certain varieties of apple, but the fact has not been established. In general, the conditions appear on fruit grown at low temperature and without sufficient sunlight. This basic relation was demonstrated in New York *(125)* by shading certain limbs of the tree, which increased susceptibility of McIntosh to brown core. In California *(97)* the shading of entire trees of Yellow Newtown increased susceptibility to internal browning. Both disorders are increased by low-temperature storage (30° to 32° F.).

BROWN CORE

In the United States brown core occurs principally in New York and New England. It is more serious in McIntosh than in other varieties, but it may occur in Rhode Island Greening, Twenty Ounce, and Baldwin. It occurs throughout Canada on varieties such as McIntosh, Fameuse, Baldwin, Wagener, Grimes Golden, Gravenstein, and Yellow Newtown. It also occurs in Australia, where it is known as core flush.

There are no external symptoms of brown core; therefore it is necessary to cut the fruit to detect the disorder. It first appears as a slight browning or discoloration of the core tissue between the seed cavities (pl. 9, *E*). Later, a part or all of the flesh between the seed cavities and the core line may become brown. In other cases, especially in McIntosh, there are, in addition to the browning between the seed cavities, brown wedge-shaped streaks penetrating beyond the core line into the surrounding flesh (pl. 9, *F, G*). This stage resembles internal browning as found in Yellow Newtown. There is no sharp line separating the diseased and healthy tissues.

Brown core may be confused with cork due to boron deficiency. If the disorder is cork, however, there usually are small, corky spots scattered through the flesh in addition to any discoloration of the core tissue.

Brown core is considered to be associated with low-temperature storage (30° to 32° F.). However, the tendency for the disease to develop appears to be inherent in the fruit when it is harvested. This disease usually does not develop in stored apples until January and becomes most serious in apples stored for long periods at 30° to 32°. It increases in severity after apples are removed from cold storage.

Perhaps the most important factor predisposing apples to brown core in the orchard is an extended period of cloudy, rainy weather when the apples are coming into maturity. It has been shown that the shading of limbs with cheesecloth increases brown core, whereas the shading of individual fruits and defoliation had no effect. Certain orchard practices such as picking at the proper stage of maturity and reduction of nitrogen fertilizer have been found to decrease susceptibility to brown core in certain seasons. However, when conditions favored a serious development of brown core such measures were ineffective. Smock *(125)* considered controlled-atmosphere storage at 40° F. to be the most practical means of preventing brown core.

(See *71, 97, 123, 125.)*

INTERNAL BROWNING

Internal browning is decidedly regional in its occurrence. It is particularly serious in Yellow Newtown apples grown in the Pajaro Valley in California, and it occurs also in Yellow Bellflower and other varieties grown in that section, where the weather is cool and cloudy or foggy through the growing season. It is occasionally found in Yellow Newtown grown in other States, notably Washington, Oregon, and New York, and in Rhode Island Greening grown in New York. Traces of the disease have been found in Virginia-grown Yellow Newtown, but ordinarily conditions there do not favor development of the disorder.

Internal browning does not manifest itself by any abnormal appearance of the skin of the apple and can be detected only by cutting into the fruit. Rather frequently it appears only around the core, the outer fleshy portion of the apple remaining normal in appearance. Occasionally only the outer flesh is involved; usually, however, when internal browning develops in the outer fleshy portion it is accompanied by browning around the core. The general tendency of the disease is to develop uniformly throughout the tissue (pl. 9, *C, D*). Internal browning occurs in firm, sound-appearing apples; this fact, together with the characteristics just given, separates it readily from internal breakdown. The latter develops in overripe apples, usually appearing on the skin and progressing in localized areas into the flesh.

The tendency to develop internal browning in storage is inherent in the fruit when it is harvested. In addition to low temperature and lack of sunlight, certain other factors have been found to increase susceptibility. The Yellow Newtown has been found to be more subject to internal browning when the fruits are large, especially from trees bearing a light crop, when they are harvested late, and when they are delayed in reaching storage. The usual cold-storage temperatures (30° to 32° F.) are particularly favorable to development of internal browning. The brown-

ing increases with the length of the storage season and after withdrawal from storage. Control can best be effected by prompt storage at a temperature of 36° to 40°.

(See *7, 12, 59, 70, 97, 140.)*

Brown Rot

(*Sclerotinia fructicola* (Wint.) Rehm [5])

OCCURRENCE AND SYMPTOMS

Brown rot may affect apple, pear, and quince in practically all producing sections of the eastern United States. It is more common on early than on late varieties, but it has been found on Gravenstein and other fall varieties in the humid districts of Washington and Oregon. The rot occasionally occurs on fruits on the tree, but it seldom causes serious loss in commercial shipments or storage lots.

Brown rot occurs almost always as a rather soft, but not mushy decay. The spots are brown at first (pl. 5, *H*); but, as they enlarge and ultimately involve the whole fruit, they become black all over or in irregular blotches. In a moist, warm atmosphere the fungus appears on the outside as grayish spore-bearing tufts, varying in size from mere pin points to patches ½ inch or more in diameter. Under dry, cool conditions the tufts are rarely seen.

Brown rot often resembles black rot so closely that positive diagnosis is difficult. There are some points of difference, however, which should be kept in mind. Apples in the early stages of brown rot frequently show circular black spots about ⅛ inch across, each with a lenticel at the center, and scattered over the otherwise uniformly brown, rotted area. Apples in the early stages of black rot at harvesttime have either a solid reddish-brown color or alternating zones of light and dark brown. Black rot becomes darker brown or even black and may have numerous small black fruiting bodies (pycnidia) scattered over the rotted area. As brown rot develops it becomes darker, often black. At this stage the surface of the rot has a velvety sheen, and characteristic gray fungus tufts may appear. Apples affected with brown rot show some degree of blackening at an earlier stage than those affected with black rot, and they shrivel sooner.

CAUSAL FACTORS

Brown rot of apple, pear, and quince is caused by the same fungus that causes brown rot of stone fruits. It is sometimes found on apples while they are still on the tree, especially in orchards where stone-fruit trees have been planted as fillers; but usually it does not attack apples until after they are harvested.

CONTROL MEASURES

Brown rot is checked by low temperatures, more readily in very early stages than after it becomes well established in the fruit. Like most other apple rots, therefore, it can be controlled fairly well after harvest by placing the fruit under refrigeration as soon as possible. Recommendations of the local agricultural experiment station should be followed for control in the orchard.

(See *12, 59, 65, 114.)*

[5] Syn., *Monilinia fructicola* (Wint.) Honey.

Bruises

BRUISES BEFORE HARVEST

Bruises produced before apples are mature are usually firm and dry as compared with the other types described. Preharvest bruises may be caused by orchard machinery, by the pressure of fruit against limbs, by hail, and by hitting fruit with ladders or with other fruit dropped during thinning. As the fruit continues growth the injured area becomes flattened or sunken and the tissue below becomes dry and spongy. In cases of slight injury no scarring of the skin is produced. Some bruises, however, develop corky scar tissue over the surface of the skin at the focal point of injury.

PACKING BRUISES

When apples are handled roughly during picking and packing, bruises that are easily recognized afterward as the result of such handling are produced. These bruises are usually not large, and the skin covering them is only slightly discolored if at all. The bruised flesh becomes brownish and in most instances shows lines of fracture that are roughly parallel to or curved slightly away from the surface of the fruit. Except for a few days after bruising takes place, the injured flesh is dry and corky.

Bruises produced when the cover of a container is forced into place over a full, tight pack may be decidedly flattened and 1 inch or more in diameter, especially on apples next to the lid of a basket or box. In cross section the bruised area is often conical and extends deep into the flesh, sometimes clear to the core. At such places the flesh inward from the skin for about ¼ inch is brown and that nearer the core has a water-soaked, glassy appearance. Away from the lid or sides of a basket or box, the bruises are likely to be concave, particularly if the fruit is ripe and soft, because of the forcing of one apple against and into another. The flesh around the outer edge of the bruised region in a ripe apple, when observed in cross section, may show a water-soaked, glassy condition. Beyond this may appear a zone of unfractured brown flesh in which delicate brown lines (small vascular bundles) can be seen.

Packing bruises can be largely avoided by careful handling methods.

TRANSIT BRUISES

Apples coming out of storage are riper and are therefore more subject to bruising during the transit and handling operations necessary to distribute them on the market. Bruising has been found to be the most serious defect of apples in the retail trade. At that stage in marketing, of course, it is the total accumulation of all types of bruises that causes such reduction in quality.

One of the more serious types of bruising occurs in boxed apples in transit. The injury is usually found only in the apples that are at the lower side of the bottom layer of boxes in the car and for this reason is frequently thought to have been caused by freezing (p. 30). It is more common during the winter than during the fall and spring, but it has been found in boxed apples shipped in the fall before freezing weather has occurred either in the producing

sections or anywhere along the routes taken by the shipments. The injury has been found also on fruit removed from storage so late in the spring that there was no possibility of its having been exposed to freezing weather in transit.

The following are the characteristics of transit bruising of apples. There are flat, bruised areas on the sides that were in contact with the lower sides of the boxes as the latter lay in the car. The bruised spots have a water-soaked, darkened appearance, are generally very firm, and may be 1 inch or more in diameter (pl. 10, *A*). Occasionally the skin covering them is discolored in spots or streaks. In cross section there is usually a water-soaked, glassy, wedge-shaped area extending from the skin toward the center of the apple (pl. 10, *B*). This area may be shallow or may extend almost to the core. In some instances the inner edge of the area appears as a fairly smooth curve, convex toward the core; in others it is broken by strands or rays having the water-soaked appearance just mentioned and extending radially for as much as ¾ inch beyond the main affected area. Small water-soaked patches or streaks are sometimes seen also underneath bruises produced by the pressure of one apple against another.

Glassy, water-soaked bruises are not necessarily a sign of freezing injury; nor are wedge-shaped injured areas that extend to the core or brown bruised spots under the skin, in which vascular browning has occurred. Investigations have shown that bruises like those just described can be produced by subjecting apples to a jolting similar to that they would receive while in transit by rail.

In addition to the types of bruising just described, there are ordinary bruises produced during the many handling operations of loading, unloading, and removing the packages into retail channels. These bruises are of various sizes, are soft, and may appear water-soaked at first; generally they become discolored. In cross section definite fractures are evident, and the injured tissue is somewhat pulpy (pl. 10, *C*).

Transit bruises can be greatly reduced by not overfilling the packages and by placing cushioning material, such as corrugated-paper liners, between the apples and the sides of the boxes to absorb the vibrations that cause the bruising.

(See *43, 116.*)

Bull's-Eye Rot

(*Neofabraea perennans* Kienh. and *N. malicorticis* Jacks.)

CAUSE, OCCURRENCE, AND SYMPTOMS

The name "bull's-eye rot" is applied in this publication to rots caused by two fungi found on apples grown in the Pacific Northwest including British Columbia. One of them, *Neofabraea perennans,* causes perennial canker, which is more or less prevalent on apples grown in all the irrigated districts east of the Cascade Range; the other, *N. malicorticis,* causes northwestern anthracnose, which occurs principally on fruit grown in the more humid districts west of the Cascade Range, but it has been also reported in certain of the more humid parts of the irrigated districts east of this range. These closely related fungi cause rots so similar in appearance that an experienced pathologist has difficulty in

distinguishing them. Therefore, no attempt is made here to separate them.

Spores that cause bull's-eye rot are present when the fruit is stored. The rot develops slowly at cold-storage temperatures and makes its appearance on apples late in the storage season, during transit, and on the market. It does not spread from one fruit to another. All varieties are susceptible, but the rot is most frequently seen on Winesap, Yellow Newtown, and Delicious.

The spots of bull's-eye rot may be only specks, but they are mostly ½ to 1 inch across. They may occur singly or may be numerous. The color may be pale yellowish cream or uniformly brown, but a spot is most often brown with a pale center that forms a bull's-eye (pl. 7, *C, D*). The spots are flat to sunken, and the rotted tissue is firm. The surface skin does not break easily under slight pressure. The rot may be shallow or nearly as deep as wide. In the deeper rots the penetration is more or less U-shaped. Ordinarily the decayed tissue is somewhat mealy and does not separate readily from the healthy tissue. Spore tufts of the causal fungus may or may not be present on the surface of the rot, but those that are present are short, wet, and cream-colored and protrude through the skin.

Bull's-eye rot closely resembles fisheye rot, but it can be distinguished from it by being less firm and having a mealy texture. In fisheye rot the surface is tougher, and the decayed tissue is dry and stringy. Fisheye rot may be accompanied by mold, consisting of white cobweblike strands spreading over the surface of the fruit.

Bull's-eye rot may also be confused with side rot at times, but generally it is quite distinct when examined closely. The skin over areas affected with side rot is very tender and breaks readily under slight pressure. Side rot is usually shallow, saucer-shaped, and wet and is easily scooped out from the healthy tissue.

CONTROL MEASURES

The decay is usually worse when rain is prevalent during harvest and when the apples are delayed in reaching cold-storage temperatures. Prompt storage and cooling of the fruit will, therefore, prolong its life and reduce decay. Sodium chloro-2-phenylphenate is being used as a disinfecting wash in the Northwest to reduce bull's-eye and other rots on stored apples. (See Pears, Gray Mold Rot, p. 59.)

(See *12, 26, 59, 60, 65, 72, 114, 136, 144, 145.*)

Chemical Injuries

INJURY BY SALT, LIME, OR FERTILIZER

When railroad cars are used for the shipment of salted hides, salt, lime, or fertilizers, either in bags or in barrels, there is usually some spilling onto the car floor and walls. If such cars are used afterward for shipment of fruit in bulk, there is bound to be, at various places, close contact under pressure between the spilled chemical and the fruit. When this occurs, the skin and underlying flesh of the fruits immediately in contact with the chemical become brown and leathery. If salt is the chemical

concerned, it can often be detected by tasting the injured flesh. Fertilizers and lime are less easily detected in this way; therefore, when injury is found and either of these substances is suspected of being the cause, diagnosis depends chiefly on whether the substance can actually be found on the car floor and walls. Injury comes about only where the fruit lies in contact with the chemical, and it is usually more severe in the layer next to the floor than in that next to the wall. It is due apparently to the forcing of the fruit into or against the chemical by the weight of the overlying load combined with the rubbing and bruising that result from the constant jolting and shifting about of the load in the moving car.

INJURY BY HYDROCHLORIC ACID

Injury to apples caused by hydrochloric acid used in washing treatments appears typically as a bleaching of the skin. It usually appears within a day or two after washing. At first the color seems merely to fade into the flesh and the skin softens, but later the skin may crack through the center of the spots and become dry and papery. With age the spots become depressed, and sometimes the presence of dissolved arsenic in the acid washing solution causes them to turn black. The appearance and severity vary somewhat with different varieties. Sometimes a few tiny black freckles found at lenticels on stored fruit, especially Winesap and Arkansas Black, may be the only indication of acid injury. Such spots might easily be mistaken for Jonathan spot.

Acid injury is sometimes localized in the stem or calyx region or at points where the apple has remained in contact with other objects; but usually the injured areas are scattered irregularly over the apple, marking places where drops of acid washing solution evaporated. Where drops of solution have concentrated to an injurious strength through evaporation, the outline of the affected area is usually circular (pl. 5, *A*); but where acid has accumulated between an apple and some other object in contact with it, the outline may be quite irregular.

Acid injury can be prevented by careful attention to the instructions given in Technical Bulletin 245 *(46)* for the use of hydrochloric acid solutions for washing apples. Of special importance in preventing acid injury is a thorough rinsing of the fruit after it passes through the washing solution.

(See *46, 136.)*

INJURY BY ALKALINE SOLVENTS

Although hydrochloric acid is the solvent commonly used for the removal of arsenical-spray residue, a number of alkaline materials, including solutions or mixtures of sodium hydroxide, sodium carbonate, trisodium phosphate, borax, sodium silicate, and other substances, are also employed. These solvents are sometimes used at a temperature of 100° F. or higher. Arsenical injury occurs somewhat more commonly on apples washed in alkaline solvents than on those washed in hydrochloric acid. Because an alkaline solvent is much more difficult to rinse off than the hydrochloric acid solution, apples washed in the former often

retain some of the solvent in the calyx cavity, where it continues to react with residual lead arsenate and forms the injurious soluble arsenic. Occasionally the alkaline solution itself causes chemical injury. Such injury is usually localized around the stem or calyx, but it is sometimes found also at the lenticels (pl. 5, *B*). The skin becomes dry, papery, and tightly stretched—but seldom cracked as in the case of hydrochloric acid injury—and is often torn loose from the underlying fleshy tissues. The skin color is yellowish or brownish yellow, except when a considerable quantity of arsenic is present; in that case it becomes dark brown or black.

(See *46, 136.)*

INJURY BY SOLUBLE ARSENIC

The injury that has sometimes been called calyx scald, or water scald, should be designated as arsenical injury. It usually occurs as depressed black or brownish spots in the calyx cavity, often encircling the calyx; but occasionally it is found in the stem basin. Sometimes the flesh is killed to a depth ½ inch or more. When the skin is killed the apple is readily attacked by decay fungi.

Arsenical injury on harvested fruit may be produced in several ways: (1) By allowing heavily sprayed fruit to remain wet for several hours before the spray residue is removed (in this case the injury is due to the soluble arsenic in the spray residue and may occur on the trees before picking); (2) by prolonged use of washing solutions in which dissolved arsenic has accumulated in toxic amounts; and (3) by use of faulty rinsing facilities, which permit some of the solvent to remain in the calyx region, where it continues its solvent action on arsenical-spray residue not removed in the washing treatment.

Arsenical injury may appear within a week or two after washing, but it usually requires several weeks to develop on all the apples that may be affected in any lot. It seldom if ever occurs on the cheek of the fruit. Chemical injuries appearing on the cheek of washed apples are usually due to the solvents employed for spray removal. Dissolved arsenic present in washing solutions often causes such injured areas to turn black; but the primary cause of damage in those areas is not arsenic but the solvents used for spray removal.

(See *46, 57, 90.)*

INJURY BY SULFUR DIOXIDE

Apples are sometimes injured by accidental exposure to sulfur dioxide escaping from a refrigerating system in which this gas is used as the refrigerant. Small quantities of sulfur dioxide (50 to 100 parts per million) present in a chamber containing apples have been found to produce injury. Such injury usually consists in decolorized, whitish papery spots at the lenticels. If the concentration of the gas is high and remains so for several days, all the skin of fruits exposed to it becomes decolorized if the apple was yellow or it bleaches to a uniform pink if the apple was originally red; the flesh becomes soft and rubbery and usually has a strong, nauseating sulfurous flavor.

Codling Moth Injury

(*Carpocapsa pomonella* (L.))

OCCURRENCE, SYMPTOMS, AND EFFECTS

Wormy fruits, injured by the larvae of the codling moth, may be found on the market among apples and pears grown in all producing sections of the United States, the proportion of injured fruit varying with the locality in which the fruit was grown and the care with which the fruit was grown and graded.

Typical wormy apples (pl. 15, *B*) are too well known to require an extensive description. The worm may enter at the calyx, at the side, or at the stem end of the fruit, and it tunnels more or less directly to the core. The area surrounding the core becomes a mass of dark-colored frass and fragments of fruit tissue. In leaving the fruit, the larva usually goes directly from the core to the side. The tunnels permit the entrance of blue mold, *Alternaria*, the black rot fungus, and other rot-producing fungi. A second type of damage, known as "sting injury," or "worm sting," consists in small, discolored, hardened, often depressed spots, usually with a tiny hole at the center (pl. 2, *G*). These spots are caused by larvae that have consumed a fatal dose of poison but have managed to burrow a short distance into the fruit before death.

CAUSE

The worm, or larva, causing worminess in apples is about ¾ inch in length when full-grown, is cream white to pink white in color, and has a dark-brown head. The insect hibernates in the larval stage in cocoons in bark crevices, in trash on the ground, in orchard lug boxes, and in packing sheds. The adults begin to emerge during or shortly after the blooming period. The moths have a wing expanse of ½ to ¾ inch; they are brownish gray in color and have a dark-brown spot crossed by two golden bars at the tip of each fore wing.

CONTROL MEASURES

For many years the standard material for control of the codling moth was lead arsenate. In some localities control with this material was very satisfactory, but in others lead arsenate was inadequate even with eight or more applications in the course of a season. Use of lead arsenate also sometimes resulted in excessive residues on harvested fruit, which had to be removed by washing or otherwise. During the last few years DDT has given outstanding control of the codling moth, and it is now being used in most localities where difficulty has been experienced in worm control. Use of DDT has unfortunately resulted in marked increases in other orchard pests, especially mites, red-banded leaf roller, and woolly apple aphid. Fully satisfactory programs for control of all of these pests have not yet been developed. More recently parathion has come into use for codling moth control. In planning a season's codling-moth-control operations, growers should therefore be guided by the current recommendations issued by State agricultural experiment stations or by the United States Department of Agriculture.

(See *47, 48, 93, 101.*)

Core Rot

(*Penicillium, Alternaria, Rhizopus, Physalospora,* and *Fusarium*)

Apples that look sound externally are sometimes decayed at the core. The condition is due to infection by some of the common rot-producing fungi following codling moth or less frequently injury by the lesser appleworm. Core rot sometimes follows cracking at the calyx end or is associated with the condition, seen occasionally in Delicious, Grimes Golden, and a few other varieties, in which open calyx tubes furnish a passageway from the outside into the seed cavities. It was found more commonly on apples washed by submersion methods that permit infected washing solutions to penetrate into the core. Core rot is generally not a major cause of loss.

Cork (Boron-Deficiency Cork)

The term "cork" as used here applies to those symptoms on apples brought on by boron deficiency. There are two phases of this disease on the fruit: namely, external cork, characterized by surface spots, and internal cork, characterized by lesions in the flesh.

The external-cork symptoms of boron deficiency may be manifested within 2 weeks after the petals fall or may appear first as late as 8 weeks after bloom. The spots appear water-soaked at first; then they rapidly turn light brown and become wrinkled, and droplets of sap exude over the surface. The exudate dries, becomes hard and brittle, and is lost through weathering. The affected areas are ½ to 1 inch across and round to irregular in shape and have rounded margins. There may be one or more lesions on a fruit. In general the lesions are superficial, but they may extend to a depth of $\frac{1}{16}$ inch or more. As the fruits develop, the affected areas crack and corky tissue develops, giving the appearance of severe spray injury such as sulfur burn. Apples seriously affected with external cork frequently drop before reaching maturity, and those remaining on the tree are likely to be deformed.

Internal-cork symptoms are confined to corky spots occurring anywhere in the flesh between the skin and the seed cavity. Deep-seated spots around the core line, often accompanied by a browning of the core tissue, are the most positive symptoms of internal cork. In moderate cases the spots are most likely to be found in the stem end of the fruit, but in severely affected apples the spots may occur throughout the flesh. In cross section cork appears as patches of dead brown tissue, often in close association with the vascular strands, or bundles that conduct food and water through the fruit (pl. 4, *E, F*).

Whether external or internal cork develops depends upon the variety of apple and the date at which the disease starts. When the disease is initiated within 6 to 8 weeks after the petals fall, the variety largely determines whether the lesions will be predominantly external or internal. In New York *(19)* under the conditions just mentioned, Macoun, Baldwin, Rome Beauty, Northwestern Greening, Jonathan, and Wolfriver develop mostly external cork, but some internal cork may occur. In Fameuse, Ben Davis, Cortland,

and Rhode Island Greening internal cork predominates and the surface of the apple remains normal. Wealthy, McIntosh, Oldenburg (Duchess), and Northern Spy usually have both external and internal cork. Regardless of variety, when the disease develops 8 weeks or more after petal fall cork is usually entirely internal. In some varieties the internal cork spots are accompanied by certain external symptoms, less severe and of a different character than those described for external cork. In other varieties there are no external signs of the disease.

It is sometimes difficult to distinguish mild surface cork, bitter pit, and stigmonose, because each may have as a symptom a corky spot immediately below a surface depression. It is safest to diagnose a disorder as cork only when additional corky spots are located deep in the flesh near the core. The diagnosis can be made with assurance if the spots are confined to the stem end of the apple.

The ordinary type of bitter pit, with relatively small pits—often in considerable numbers—located around the calyx end of the fruit, is readily recognized. The pits and the corky spots are smaller than the surface depressions and corky spots associated with cork. Like cork spots, however, bitter pit spots are associated with the vascular bundles.

When bitter pits occur deep in the flesh it is much more likely to be confused with cork, especially if the surface depressions and corky spots are larger and fewer in number than when bitter pit occurs at the surface. The disorder would be recognized as bitter pit rather than cork if the spots are more or less confined to the calyx end and do not occur around the core.

Internal cork spots adjacent to the peel and beneath surface depressions are very similar to stigmonose. The two disorders may occur on the same fruit. Spots of corky tissue adjacent to the peel and in conjunction with flattened or broadly depressed surface spots occurring anywhere on the fruit, with no cork spots deeper in the flesh, are most likely to be stigmonose (pl. 4, *G*, *H*).

Besides the surface depressions similar to stigmonose, there are other surface characteristics that may accompany internal cork. Some varieties show dimplelike depressions, and in others the surface is pebbly, lumpy, or corrugated. It is thought that the stage of development of the fruit when the disease starts affects the occurrence and extent of external symptoms accompanying internal cork. Perhaps most varieties show some external symptoms in severe cases. Because of the nature and complexity of the disorder, however, it is best to make a diagnosis from the location of internal cork spots rather than from the external characteristics.

Diseases of the cork type are widely distributed. They have been reported from all the important apple districts of Washington and Oregon, from New York, from various apple districts of Virginia and West Virginia, and from British Columbia and New Zealand. The trouble known in California as hollow apple seems to be very closely related to cork.

In New York, Cortland, McIntosh, Fameuse, Oldenburg, and Ben Davis are among the varieties most severely affected. Wealthy is moderately affected; and Baldwin, Northern Spy, Jonathan,

Northwestern Greening, Rhode Island Greening, Golden Delicious, and Delicious are less commonly affected.

In the Shenandoah-Potomac valley districts, orchards of Ben Davis, Gano, and Oldenburg are most frequently affected. Yellow Transparent, Jonathan, Rome Beauty, and Grimes Golden have also been found affected in these districts *(34)*.

In the Pacific Northwest cork has been observed on most varieties. It is probably most serious on Yellow Newtown, Rome Beauty, Jonathan, and Winesap. The Delicious variety may in some cases benefit from boron fertilization even though none of the usual deficiency symptoms are evident. It has been found that where boron is lacking the fruit does not attain its characteristic shape. The apples are inclined to be flat, with little tendency toward prominent lobing at the calyx end *(8)*.

Apples affected with cork usually ripen a week or two earlier than normal fruits, and their color is dull. When stored they may develop characteristic symptoms of internal break-down like fruit that is overripe when stored.

Cork is a symptom of boron deficiency in the tree and occurs when the boron supply in the soil is inadequate. There is some evidence that extended drought increases the symptoms, probably by preventing the tree from obtaining sufficient boron for normal development of the fruit. It has been found that root injury resulting from disking or waterlogging of the soil increases boron-deficiency symptoms.

Control of the disease depends on application of boron in the form of boric acid or borax to the soil or by spraying the trees, when in leaf, with a weak solution of either of these chemicals.

(See *3, 4, 8, 18, 19, 34, 40, 49, 78, 82, 84, 137, 142.)*

Drought Spot

The name "drought spot" came into use in 1916 when Mix *(89)* described it along with cork, a disease that had been known for many years. The two diseases were considered to have similar causes. Cork is now generally ascribed to a lack of boron. Boron deficiency is also regarded as the cause or one of the principal causes of certain other symptoms previously identified as drought spot or heat injury. Now that some of the underlying causes of these disorders are better known, and since there appears to be no accurate description of drought spot that sets it apart from cork and heat injury it seems best to discontinue the use of the name. (See Cork (Boron-Deficiency Cork), p. 27, and Heat Injury, p. 37.)

(See *13, 84, 89.)*

Fisheye Rot

(*Corticium centrifugum* (Lév.) Bres.)

Fisheye rot occurs on apples grown in the Pacific Northwest including British Columbia and also on those grown in eastern United States. In western apples it is difficult to distinguish from bull's-eye rot. The spots may be only specks or up to 1 inch in diameter, but most of them are less than 1 inch unless several coalesce. The surface of a spot is usually brown and the center pale, but a spot may be cream-colored or uniformly brown. The

rot is firm, the skin is tough and leathery, and the larger spots are sunken. The decayed tissue is spongy or stringy and does not separate readily from the healthy tissue. The rot is easiest to identify when accompanied by a surface growth of white cobweblike mold. Fisheye rot differs from bull's-eye rot in not having spore-bearing mold over the rot spot and in having dry, spongy or stringy decayed tissue.

The occurrence of fisheye rot seems to be associated with an abundance of rainfall prior to and during harvest. In the East fisheye rot frequently follows scab (pl. 7, *G, H*), which is favored by similar weather conditions.

Fisheye rot, like bull's-eye rot, can develop at 30° to 32° F., but only slowly, and is not often found in stored fruit until late in the storage season. No evidence has been seen that it can spread in transit or storage.

The decay is most common on windfalls and perhaps on those apples hanging near the ground. The reason is that the causal fungus is present on decaying weeds or cover crops. Consequently, apples that have dropped to the ground should never be packed with fruits intended for storage, even when they are apparently sound.

(See *20, 60.*)

Flyspeck

(*Leptothyrium pomi* (Mont. & Fr.) Sacc.)

Flyspeck (pl. 1, *D*) is well described by its name. The specks occur in areas usually not more than ½ inch in diameter and, like sooty blotch, are easily scraped off. The two diseases are usually associated, but they are caused by different fungi.

Flyspeck is of importance on the market only because of its effect on the appearance of the fruit. It can be controlled by the treatment recommended for scab.

(See *59, 65.*)

Freezing Injury

Freezing injury is a common cause of loss in apples during the winter months. The greater portion of it occurs in transit, especially in fruit shipped eastward from the Pacific Coast States, which must pass through high-altitude country and remain at extremely low temperatures, often for several days. However, apples that show evidence of freezing injury upon reaching the market have not necessarily been frozen in transit. Freezing in the orchard sometimes occurs both in the East and in the West. There are also occasional opportunities for freezing injury during the handling or the storing of fruit previous to its actual shipment.

At present there are no known symptoms of freezing injury that clearly indicate, for a single apple, the time when or the conditions under which the damage occurred. The distribution of the injury in the car indicates whether freezing occurred prior to loading or during the transit period. Transit freezing occurs in cars without forced-air circulation first at the doorway, along the floor and side walls, and near the bunkers; upon prolonged exposure of the fruit to low temperature, injury may extend deeper into the load. If freezing injury is not present in the

outer parts of a load, there should be no transit freezing elsewhere in the car. If the injury is uniformly scattered through the packages and through the load, in all probability freezing took place before the product was loaded.

The amount of injury that an apple may suffer from freezing depends on the length of the exposure to low temperature, on how low the temperature goes, and on other conditions affecting the fruit when freezing occurs. Usually these conditions, as well as the rate of thawing, are unknown when apples are inspected and conclusions must be drawn from the appearance of the fruit at that time.

When apples freeze, ice crystals form within the tissues, not in the cells but between them. The quantity of ice which forms depends on the duration of cold and the minimum temperature which the tissues reach. As the tissue temperatures fall, more and more water is withdrawn from the cells and greater quantities of ice form. Formation of a small amount of ice in the tissues causes little damage if the fruit is not handled while frozen, as would be the case while the fruit is on the tree. If the temperature of the tissues becomes sufficiently low to build up large quantities of ice, however, serious injury or death of tissues results.

The presence of ice in an apple at the time of examination is not evidence that serious freezing injury has occurred. Doubtless any ice formation injures the apple flesh to some degree, but there is no visible evidence of injury from slight freezing and no effect upon the market value of the fruit. If the freezing process proceeds somewhat further, however, a slight noticeable injury results, even though the cells may appear practically normal; if it proceeds still further, the cells may be killed and turn brown. Unless a significant proportion of the cells show this browning it is inaccurate to say that an apple shows freezing injury.

FREEZING POINT OF APPLES

Accurate determinations on several hundred specimens of the more important commercial varieties of apple (Winesap, Stayman, Yellow Newtown, Ben Davis, Baldwin, Rome Beauty, Wagener, Jonathan, McIntosh, Tompkins King, and Grimes Golden) showed that the freezing point ranges from 27.3° to 29.4° F.; the average is 28.4°. Unless the temperature of the air surrounding an individual specimen is suddenly lowered much below 27° to 29°, the temperature of the inside tissues often drops temporarily a degree or more below the true freezing point without any formation of ice. This phenomenon—lowering the temperature of the tissue below its freezing point without inducing the formation of ice crystals—is known as undercooling. If the temperature continues to fall or if the exposure to the low temperature is prolonged, the resistance to freezing is overcome, the undercooling period ends, ice quickly forms in the tissues, and the temperature rises rapidly to the approximate true freezing point regardless of the air temperature around the apples. After ice forms in the tissues a further drop in the temperature of the surrounding air will be reflected in the temperature of the fruit.

SYMPTOMS OF FREEZING INJURY

External Appearance

If freezing has been slight, there may be no marked external symptoms of any sort; if it has been severe, the general outside appearance of the apple is strikingly affected. The surface becomes discolored in irregular-shaped areas very soon after the apple thaws and appears considerably darkened. It often assumes a water-soaked appearance and a brown color closely resembling the color of apple scald. It may become much darker, in some cases almost black. When apples are in a frozen condition the skin becomes temporarily shriveled, the shriveling usually occurring in the form of a network of wrinkles rather than as parallel lines of shrinkage such as are produced by normal evaporation. Careful measurements have shown that the fruit actually becomes smaller, sometimes by as much as 10 percent of its original volume. The reduction in size is shown also by the fact that if the apples in a packed box or basket become frozen they rattle around when the container is shaken, even though the pack was tight before freezing occurred. On thawing, the pack regains practically its original volume, unless the freezing was very severe.

When an apple thaws after having been badly frozen the skin becomes shriveled, particularly if the air in the storage place is very dry. This form of shriveling seems to be due to rapid evaporation of the water withdrawn from the cells and changed into ice in the spaces between the cells during the freezing process. Shriveling, when slight, is accompanied by a reduction chiefly in size; when severe, by a marked reduction in both size and weight.

Apples that have been severely frozen frequently show noticeably sunken spots, which may be ¼ inch deep or more and have a superficial diameter about equal to their depth. In virtually all cases these sunken spots develop at places that were bruised while the apple was still frozen. (See Bruises, p. 21.)

Apples that have been both bruised and frozen while in transit by rail frequently show flattened areas, 1½ to 2 inches in diameter, that are somewhat sunken and soft toward the center and have a dull-brown or slate color over most or all of the surface. Transit bruises, described on page 21, are smaller in diameter, and flat instead of sunken, the skin covering them is not slate-colored, and the flesh beneath is firm.

It should be remembered, however, that during a short exposure to an air temperature several degrees below freezing considerable ice may form within the tissues and yet produce little or no effect that could be diagnosed as freezing injury.

Internal Appearance

Usually the best indications of freezing injury are found by examining a cross section of the fruit. If a cut is made crosswise through the middle of an apple that has not been frozen, there will be seen, about halfway between the center and the outside, 10 small dots, the natural color of which in most varieties is green or yellowish green, but of which in Winesap, Esopus Spitzenburg, and some other varieties is occasionally tinged with red. These dots are the cut ends of the main fibrovascular bundles of the apple, which are connected with numerous but less conspicuous

threadlike fibers extending throughout the flesh. The whole network, including the large bundles, constitutes the vascular (food- and water-conducting) system of the fruit and, so long as the fruit remains on the tree, is in direct connection with a similar system in the twigs and branches.

When freezing occurs the cells of the vascular system are usually the first to be affected, especially if freezing takes place rapidly; and they may be the only ones affected. In cross section this injury is shown by a brown discoloration of the 10 large main bundles (pl. 10, *D*), the color being visible evidence that the cells have been frozen to death. Similar browning may occur in the smaller strands through the flesh and in the core tissues; it is frequently restricted to one side of the apple because of lower temperature on that side. In more extreme cases all the tissues may be affected; the flesh then shows throughout a solid color which varies from bright golden brown to darker brown or almost black, depending on the variety of apple and the severity and freshness of the freezing injury (pl. 10, *E*). The browned areas, in whatever tissue found, usually have a water-soaked appearance and if the injury is mild are translucent.

EFFECT OF FREEZING AND THAWING

It is generally believed that frozen apples are injured less by gradual than by rapid thawing. While evidence on this question is not altogether clear, somewhat more severe injury has been found when the fruit is thawed at 65° F. than when it is thawed at 32°.

Apples that have been frozen are often dry and mealy, probably because of loss of water through evaporation from the injured tissues. The degree of mealiness increases with the amount of freezing, but mealiness is not entirely absent even when freezing is only slight. The flesh sometimes appears flaky or corky and always lacks the normal crispness; in severely frozen specimens it collapses and becomes viscid, soft, and mushy.

If apples are frozen but not frozen to death, they may thaw out with no apparent aftereffect except a slight softening of the flesh. This softening, however, means that the prospective storage life has been shortened. The amount of the reduction depends on the variety, the degree of maturity of the fruit when frozen, and the severity of the freezing. Unquestionably, apples that have been solidly frozen throughout, even though for only a short time, will not hold up so well in storage or for so long a time as similar apples from the same orchard or the same storage lot or shipment that have not been frozen.

Apples should not be handled while frozen, because of the danger of serious damage from bruising. Bruises produced in this way frequently extend deep into the fruit, and the affected flesh usually becomes brown, soft, and somewhat watery.

FREEZING INJURY AND INTERNAL BREAK-DOWN

During January or even earlier and through the remainder of the storage season, it may sometimes be difficult to distinguish freezing injury from the condition known as internal break-down due to overripeness. The difficulty will be greatest when there is

no evidence of freezing in transit. Internal break-down may be followed by browning, but this color change, unlike that which often follows freezing injury, does not begin in the main fibrovascular bundles (in cross section, the 10 dots that surround the core). Instead, it may begin at any place in the flesh and usually does begin at many places. (For further description of internal break-down, see page 37.)

Internal break-down is usually worse in large apples and more marked at the calyx end than at the stem end. Freezing injury may affect apples of any size and is not necessarily or uniformly worse at one end of an apple than at the other. When one side of an apple or even the whole apple shows in cross section a uniform brown color, it is hard to determine whether the condition is freezing injury or internal break-down. Reliance should then be placed not on any one symptom or the examination of one apple but on all the symptoms that can be found in as many apples as can conveniently be examined.

Water-soaked bruises are not a sure sign of freezing injury, as will be seen by reference to Bruises, page 21.

(See *23, 35, 77, 116, 118, 141.)*

FREEZING INJURY WHEN APPLES AND PEARS ARE YOUNG

When freezing temperatures occur at blossoming time or soon afterward, the fruits that remain on the trees may nevertheless have suffered sufficient injury so that as they come to maturity they show various abnormal conditions. One of these conditions is the familiar frost russet. Perhaps the most common form of mild frost injury is a russeted ring lining the calyx cavity and occasionally extending outward from the cavity for ½ inch or more. On apples and pears frost injury frequently takes the form of bands encircling the fruit about halfway between the two ends (pl. 3, *C*). In addition, frost russet on both apples and pears sometimes has the diffuse irregular form characteristic of spray injury and rain russet.

A second condition, seen less frequently and only on apples, is persistence of the green color at the calyx end on mature fruits which over the rest of their surface have the color normal for the variety. The persisting greening varies greatly in intensity and in the amount of surface covered. It may or may not be accompanied by russeting. Affected areas are occasionally so flattened and so dark green that they look like apple-cedar rust spots, but they do not, of course, show the pustules characteristic of rust. Badly damaged specimens are nearly always distorted at the blossom end, may have only a few poorly developed seeds or none at all, and usually show in cross or longitudinal section a blotchy or streaked browning in the flesh underlying the green areas.

Fruit Spot

(*Mycosphaerella pomi* (Pass.) Lindau)

OCCURRENCE AND SYMPTOMS

In the United States fruit spot (Brooks' spot) is most common east of Michigan and north of North Carolina and Tennessee. It is occasionally serious in southwestern Missouri and northwestern Arkansas. It causes the greatest losses in New England,

where in some years it may affect 50 to 90 percent of the fruit. In some years it has been important in New Jersey. This disease occurs also in Canada and has recently been reported in Germany and southern Africa. Varieties most seriously affected are Baldwin, Jonathan, Rome Beauty, Tolman Sweet, Grimes Golden, and Stayman. Many others have been reported as susceptible.

The spots are ⅛ to ¼ inch in diameter and deep red or black on red areas and dark green on green or yellow ones (pl. 1, *G, H*). Late in the fall or after the apples are in storage the central part of the spot becomes flecked with black, which can be observed more readily by removing the surface of the spot by making the thinnest possible paring. There will then be seen in the flesh underneath a number of very small brown or black specks, which are aggregates of cells killed by the fungus. These specks can sometimes be seen through the cuticle but are more likely then to be obscured by the surface discoloration. Owing to the collapse of the cells in the affected area, the larger fruit spots become slightly sunken. On overripe apples the spots are often surrounded by a band of brown.

Because of their speckled appearance, fruit spots caused by *Mycosphaerella* are easily distinguished from all other spot diseases of apples. They are further distinguished from bitter pit by not being markedly sunken except in later stages, by occurring only in the epidermis of the fruit, and by having no connection with the water-conducting system.

On fruit in cold storage the spots change but little. In delayed storage or in transit new spots may appear and older ones may seem to enlarge slightly. In the main the seeming enlargement results from the change in color of the fruit rather than from actual enlargement of the affected areas.

CONTROL MEASURES

Infections on the fruit appear not earlier than June and may continue until August. The disease can be controlled by spraying in accordance with the recommendations of the local agricultural experiment station.

(See *10, 12, 59, 65, 114, 132.)*

Gray Mold Rot

(*Botrytis* spp.)

CAUSE, OCCURRENCE, AND SYMPTOMS

More than one species of *Botrytis* has been reported as causing a decay of apples known as gray mold rot. The most common species is *Botrytis cinerea* Fr. Gray mold rot occurs on apples grown in the Pacific Northwest and in various producing sections in the eastern United States. It is not common and is seldom as destructive on apples as on pears grown in the Pacific Coast States. In the Northwest the Winesap variety seems to be affected more often than any other. Gray mold is second to blue mold in losses it causes in storage and handling of eastern apples.

Gray mold rot developed in cold storage is characterized by diseased areas that at first have a pale, translucent, watery appearance and remain light brown to brown. The spots are firm at first but become soft as the rot advances (pl. 6, *F–H*). Fre-

quently in the early stages of the rot there are dark-brown spots around the lenticels, about ⅛ inch in diameter, which in their final form become reddish brown and have pale or whitish centers. These spots continue to give the fruit a freckled appearance even after it is completely rotted.

The initial infection usually occurs at the stem or the calyx end. The decay spreads from an infected fruit to surrounding fruits in contact with it. Secondary infection may occur anywhere on an apple, depending on the point of contact with the initially decayed fruit. Because the fungus can grow from diseased fruits to healthy ones lying near or touching them it often produces "nests," or "pockets," of decaying fruits in the stored package. Hence, the disease is often called nest rot, or cluster rot (pl. 18). Gray mold rot develops faster at cold-storage temperatures than any other fungus rot of apples. Apples carrying infection when placed in storage at 30° to 32° F. are often completely decayed by February or March.

CONTROL MEASURES

It is believed that the source of gray mold infection is in the orchard. The fungus grows and sporulates abundantly on dead and dying plant material found in orchard cover crops, especially during cool, moist weather. Fruits hanging near the ground are more likely to become infected than those farther from it. As mentioned earlier, fruits infected at the time of storage nearly always decay at the stem or the calyx end. The spores lodge in these cavities and under favorable conditions may develop and attack the stem or calyx sepals. From such superficial infection the fungus spreads to the edible part of the fruit. Some measure of control may be obtained by keeping the cover crop closely clipped around the trees, to permit better air circulation and thus to reduce dampness and certain other factors favorable to fungus development.

Picked fruit should not be left in the orchard. Additional reduction in fruit decay may be had by using a disinfecting wash at packing time. (See Pears, Gray Mold Rot, p. 59.)

(See *11, 12, 29, 30, 59, 60, 61, 114, 136.*)

Hail Injury

Early-season hail injury generally occurs at the calyx end or on one side of an apple, because of the position of the fruit on the tree during this period. Later, when the fruit has become larger and heavier, it generally turns downward; so hail marks on well-developed fruits are more often on the stem end.

Fruits injured early tend to outgrow the internal condition produced, but they may become slightly misshapen as they develop. When fruits are struck by hail late in the season, the cuticle covering the affected spots may be cracked or torn but often remains intact. Such spots range from ¼ to ½ inch in diameter and are slightly sunken; the flesh beneath them is brown and somewhat spongy and dry, because of loss of water from the bruised area (pl. 3, *D*). The spots are usually dry enough when the fruit is shipped not to be subject to rot infection, even if there are cracks in the skin and flesh.

Hail injury can be distinguished from other spots described by the fact that only the upper exposed part of the fruit is affected. This usually coincides with the blushed area, unless fruits are injured by hail while still young and small.

Heat Injury

Apples may be injured while still on the tree by excessively high temperatures following a period of relatively cool weather. Heat injury is greatly influenced by soil moisture and is most likely to occur when the high temperature is accompanied by a sudden deficiency of soil moisture. The injury usually occurs on the exposed side of an apple and frequently at the margin rather than at the center of the most exposed area.

On slightly injured fruits the only symptom consists in isolated spots of brown spongy tissue, but on those injured to a greater extent the tissue may be in various stages of partial collapse. Sometimes an entire fruit looks as if it were completely baked. The following symptoms, however, are more likely to be seen on fruit on the market. The skin usually retains its normal appearance, but it may be of a deeper color than normal, sunburned, or even killed and brown. There is always some form of tissue collapse under the affected area, so that the surface often becomes sharply sunken (pl. 3, *G, H*). Such collapsed tissue often makes the fruit knobby or distorted. The extent of collapse depends upon the severity of the injury. The surface of the injured area may be wrinkled, depressed, or corrugated. Depressed areas are often crescent-shaped. The brown spongy tissue below the sunken surface may have irregularly shaped cracks or cavities.

(See *14.*)

Honeydew and Sooty Mold

Honeydew on apples is deposited by aphids and certain other sucking insects. This sticky substance is a favorable medium for the growth of sooty mold, which sometimes covers much of the surface of the fruit. Although this mold is superficial and usually does not affect the internal condition of the fruit, it detracts from its appearance.

Internal Break-Down

Internal break-down occurs in apples grown in all of the fruit-growing sections of the United States. It has been observed most often in Jonathan, Stayman, Rome Beauty, Wagener, and certain summer varieties that quickly become overripe; but Delicious, Esopus Spitzenburg, Yellow Newtown, Baldwin, Winter Banana, and Rhode Island Greening are also frequently affected.

Internal break-down often indicates the end of the storage life of apples when they are not affected by fungus rots. It may, however, occur earlier as a result of unfavorable growing conditions or certain handling or storage practices and may follow water core, freezing, or bad bruising. It is characterized by the breaking down and browning of the interior of the apple (pl. 9, *H*), sometimes only on one side or around a bruise and at other times throughout the flesh. Often an outer shell of healthy flesh about ¼ inch thick surrounds a brown zone that in cross section

extends inward in roughly triangular patches as far as the vascular bundles or a little beyond; next to this is another zone of healthy flesh, and in the flesh at the core is a second area of brown. The condition just described is especially common in Jonathan and Delicious. The riper side of the apple is affected more often than the greener side and the calyx half more often than the stem half. The skin of affected fruits may be normal in appearance, but it is often duller and darker than normal and in later stages of the disease it sometimes becomes cracked.

Apple flesh affected with internal break-down is usually mealy rather than wet and soggy. (See Soggy Break-Down, p. 51.)

Internal break-down is at times mistaken for freezing injury (p. 33). In distinguishing the two, it is helpful to bear in mind that a large part of the browning in frozen apples occurs at bruises extending inward from the surface and that freezing injury may occur anywhere in the apple without relation to maturity or morphology; and that, on the other hand, browning from internal break-down at a bruise rarely assumes a radial direction, is usually accompanied by a greater degree of mealiness, and includes more of the surrounding tissue.

Internal break-down occurs most often on large-size, overmature apples and on those that have been forced late in the season. It sometimes results from holding the fruit on the trees too long, waiting for color, and can often be traced to delay in cooling the fruit after it has been harvested or to the fact that the fruit has been held in storage at too high a temperature or beyond its proper season. Internal break-down also often follows water core, as previously stated, and for this reason it is usually considered hazardous to store water-cored apples. The amount and seriousness of internal break-down vary from year to year, apparently being dependent to a large extent upon growing conditions.

The little that can be done to control internal break-down after picking is best done by placing fruit promptly in cold storage at 30° to 32° F.; but fruit with a decided tendency toward break-down cannot be relied on for late keeping even in cold storage.

(See *12, 59, 92, 98, 105, 108, 114, 136.*)

Internal Browning

(See Brown Core and Internal Browning, p. 18.)

Jonathan Spot

Jonathan spot occurs on apples grown in all parts of the United States and is also known to occur in other parts of the world. The variety most commonly affected is the one on which the disease was first described, Jonathan; other varieties showing spots so similar that they are generally classed as Jonathan spot are Esopus Spitzenburg, Wealthy, Yellow Newtown, Grimes Golden, Rome Beauty, Gravenstein, Ortley, Arkansas Black, Twenty Ounce, and Wolfriver. The spotting is apparently not caused by either fungi or bacteria. It is common after a dry season and in some years is more common on large apples than on small ones. It is occasionally found on ripe apples before picking, but it is

most prevalent on apples in transit or storage, especially if temperature and humidity are high and ventilation is poor.

In the early stages Jonathan spots are brown, roughly circular areas, 1/16 to 1/8 inch in diameter, which are abruptly but only very slightly sunken; in later stages they become somewhat more sunken, are irregularly lobed, and sometimes 1/4 inch across (pl. 8, *A*, *B*). In early stages the spots are confined to the color-bearing cells of the skin, but underlying tissues become affected and dry out after the skin is killed. These spots sometimes become infected with *Alternaria* or other rot fungi.

The disease is important chiefly because of its effect on the appearance of the fruit. Its most serious characteristic is a tendency to develop in transit or storage to such an extent that marked damage results to fruit that was apparently in good condition when shipped or stored.

Brown spots that resemble typical Jonathan spot are sometimes seen on Rome Beauty apples. These seem to occur only at lenticels; they have blurred, indefinite edges, and are rarely sunken, even as slightly as the typical spots on the Jonathan variety. Nothing is known of their relation to orchard or storage conditions except that they do not usually develop until late in the storage season. In the absence of evidence to the contrary, it seems best to consider them a form of Jonathan spot (pl. 8, *C*).

The most effective method of controlling Jonathan spot is to move apples promptly into cold storage, avoiding delays at ordinary temperatures.

(See *12, 13, 43, 59, 65, 102, 105, 110, 126.)*

King David Spot

King David spot occurs on apples of the King David variety. The spots are black or dark greenish and up to about 1/4 inch in diameter and are generally confined to the skin. Occasionally they extend a very short distance into the flesh. No spots occur deep in the flesh.

King David spot is typically an orchard disease and does not develop in storage. Green and blush areas on the fruit are about equally affected; sometimes the spots are confined to the calyx cup or the stem basin.

Nothing is known of how the spot is caused or how it can be controlled.

Leafhopper Specking

After infestations by leafhoppers (several species), apples often show numerous superficial brown or black specks about the size of a pinhead or slightly smaller. These are usually most numerous on fruit that was exposed to dust when the leafhoppers were most active. The washing of fruit to remove spray residue incidentally removes leafhopper specks.

Leaf Roller and Green Fruitworm Injury

Large russeted and corky scars, often in scooped-out areas, but sometimes in the form of small, slightly raised or undulating spots, together with more or less distortion, are often found on

marketed apples. Such injuries usually are the result of feeding by certain chewing insects early in the season when the apples are small. The exact identity of the insect concerned cannot be determined after the injury has healed. Among the insects causing this type of injury are the fruit tree leaf roller *(Archips argyrospila* (Wlkr.)) (pls. 2, *E;* 17), the green fruitworm *(Lithophane antennata* (Wlkr.)) and related species, and the rusty tussock moth *(Notolophus antiquus* (L.)).

The larvae of the red-banded leaf roller *(Argyrotaenia velutinana* (Wlkr.)) consume extensive areas of skin and outer flesh, usually in the calyx or the stem end, where two apples touch or where a leaf is in contact with an apple (pl. 15, *D*). This species recently has appeared in large numbers in eastern and midwestern orchards that had been sprayed with DDT. It is usually most abundant late in the season. As a result the injured areas do not heal over, but offer a favorable opportunity for the entrance of various rot organisms.

(See *101.)*

Miscellaneous Rots

In addition to the apple rots discussed under various special headings there are others of minor importance, from which the following fungi have been isolated: *Mucor piriformis* A. Fisch.; *Endomyces mali* I. M. Lewis; *Pleospora fructicola* (Newton) Ruehle; *Mycosphaerella tulasnei* Jancz.; *Gliocladium viride* Matr.; *Phoma* spp.; *Coniothyrium* spp.; *Microdiplodia* sp.; *Pestalotia hartigii* Tub.; *Coryneum foliicolum* Fckl.; *Oospora* sp.; *Cephalosporium carpogenum* Ruehle; *Penicillium* spp. (other than *P. expansum); Aspergillus* spp.; *Trichoderma* sp.; *Cladosporium herbarum* Fr.; *Stemphylium congestum* Newton; *S. congestum minor* Ruehle; *Fusarium* spp.; *Epicoccum granulatum* Penz.; and *Ramularia magnusiana* (Sacc.) Lindau, which causes ramularia rot.

Most of these fungi grow slowly at cold-storage temperatures, and only a few are as active at ordinary temperatures as gray mold or the species of blue mold *(Penicillium expansum)* that is most common on apples and pears. The rots they cause are usually firm, vary in color from light to dark brown, and are not readily distinguishable from each other except by laboratory study. None are described here.

(See *59, 66, 94, 120.)*

Pansy Spot

Pansy spot occurs on apples as areas ½ inch or more across that are frequently lobed in a way suggesting the shape of a pansy flower. On green or yellow apples they are white or greenish (pl. 2, *F*); on well-colored McIntosh they are light red or pink. They are caused by the flower thrips *(Frankliniella tritici* (Fitch)) and probably by other species of thrips. At the centers may be found greenish-brown corky spots, seldom more than ⅛ inch in diameter, which develop around punctures made by the female thrips in the process of egg laying. The spots show conspicuously on green immature apples and often become prominent and serious defects at harvest. In particular on the McIntosh variety

the red color in the spots seems to be permanently lost. On some other varieties the spots may become rather inconspicuous as the natural coloring of the fruit develops. Evidence has been obtained that the spots do not enlarge or change in any other way while the fruit is in storage.

Partial control may be obtained by spraying the trees in full bloom with nicotine sulfate (40-percent nicotine) in the proportion of 1 pint in 100 gallons of water. Enough soap should be added to make the solution soapy to the touch, or casein spreader should be used. The addition of nicotine to the calyx spray is helpful also in controlling the thrips.

(See *25.*)

Pear Leaf Blister Mite Injury

(See Pears, Pear Leaf Blister Mite Injury, p. 60.)

Phytophthora Rot

(*Phytophthora* sp., probably *P. cactorum* (Leb. & Cohn) Schroet.)

Phytophthora rot, a parasitic disease of apple and pear, has been found on fruit grown in New York, Connecticut, Michigan, Indiana, Washington, Oregon, and Idaho. So far as known it does not cause heavy damage in any of these States, and it is not common on the market. The rot can develop slowly at cold-storage temperatures, but there is no evidence that it can spread from affected to sound fruit either in transit or in storage.

Phytophthora rot on apple, as seen from the outside, is light brown (pl. 7 *A*); on pear it is dark brown to black. In both apple and pear there is always a marked browning of the vascular bundles, or strands that conduct food and water through the fruit. This browning occurs in the large bundles near the core and the smaller ones throughout the flesh; from the former it may extend even into the stem. In apple the flesh surrounding the bundles is slightly browned; in pear it is browned scarcely at all. In some varieties of pears, notably Clairgeau, the flesh is in fact decolorized and has a clear, water-soaked appearance very much like that of apple flesh affected with water core.

The affected flesh of both apple and pear sometimes becomes slightly spongy, but it is usually as firm as sound, healthy flesh; unlike the decay produced by *Rhizopus* or blue mold, it rarely becomes soft and mushy. In cross section the area affected by *Phytophthora* in both kinds of fruit has an indefinite boundary, so that it is impossible to make a clear separation of diseased from healthy flesh, as can easily be done in fruits attacked by *Rhizopus* or blue mold. The affected flesh has no marked odor or taste.

Phytophthora lives in the soil and the apples most likely to be infected by it in the orchard are windfalls and fruits hanging low on the trees. Apparently the fungus can penetrate the uninjured skin of the fruit. On the market phytophthora rot has been found in boxed apples and in shipments of low-grade pears.

Phytophthora rot in marketed fruit can be reduced by eliminating windfalls from the pack.

(See *28, 65, 115, 134.*)

Pink Mold Rot

(*Cephalothecium roseum* (Fr.) Cda.)

Pink mold rot was formerly more prevalent and destructive than it is at present, because of the custom, now virtually discontinued, of piling apples and allowing them to sweat before packing. While pink mold rot is usually found associated with scab in the orchard, in storage, or in transit, occasionally it enters the lenticels of fruit showing neither scab nor any other injury.

In its most common form, following scab, the disease has two rather well marked stages with various transition stages between them. In the first of these the rot appears as definitely sunken brown bands about ⅛ inch wide encircling scab spots. On the rotted area there is sometimes a growth of white fungus threads or, under warm, moist conditions, a pink mass made up of these threads and the pink spores they produce. If conditions are favorable, the second or final stage of the rot soon follows. This is characterized by chocolate-brown sunken areas of irregular outline varying in diameter from ½ to 2 inches or even more. Scattered over these areas are depressed, circular spots which are lighter brown than the rotten area surrounding them (pl. 7, *B*). Under market conditions this late stage of the rot is less likely to show the white fungus threads and the pink spore masses than is the first stage. At any stage the rotted areas are rather firm and dry or at least are not watery, and the affected tissues have a bitter taste.

Pink mold rot is sometimes confused with fisheye rot, caused by *Corticium centrifugum*. The two can generally be distinguished by the fact that on a fruit affected with pink mold rot there may be a conspicuous white to pinkish growth of the fungus. Spots of fisheye rot show very little fungus growth except under conditions of high humidity, when a thin, white cobweblike mold may develop. Pink mold is a shallow-growing fungus, penetrating the flesh about ⅛ inch, whereas *Corticium* grows deeper and in its late stage may extend to the core.

Below 50° F. pink mold develops very slowly and is not at all likely to start at new places; at 32° it is checked almost entirely. Control is therefore best obtained by means of refrigeration. Infection rarely spreads from one fruit to another unless scab is present and the fruit is held at fairly high temperatures for some time after harvest.

(See *59, 65, 114.*)

Plum Curculio Injury

(*Conotrachelus nenuphar* (Hbst.))

Occurrence, Symptoms, and Effects

Injury caused by the plum curculio is often found on apples in the eastern half of the United States. Two kinds of punctures are made: those for feeding and those for reception of eggs. In feeding, the beetle cuts a small, round opening through the skin and then eats out a cavity as deep as it can reach. When abundant, this injury causes the apples to be badly deformed and misshapen (pl. 16). Punctures made for the purpose of laying eggs are partially

surrounded by small, crescent-shaped slits. As the fruit grows, these form corky, russeted scars. In the fall adult curculios of the new generation often feed on the ripening fruit, making shallow pits, mostly around the calyx and stem ends (pl. 15, *E*). These do not heal over and may permit the entrance of decay organisms.

CAUSE

Adult plum curculios are small, hard-shelled beetles with long snouts. They hibernate in trash in orchards or in brushland or wasteland nearby and begin to return to the apple trees about the time these come into bloom. Most of the egg laying and feeding is done during a period of 4 to 6 weeks after petal fall; a limited amount of feeding is done in the fall. Many of the larvae in the fruit are killed by the pressure of the rapidly growing tissue, but enough of them survive in fallen fruit to maintain the infestation.

CONTROL MEASURES

Plum curculio may be controlled by thorough spraying. The spray program should follow the recommendations of the local agricultural experiment station.

(See *101.*)

Powdery Mildew

(*Podosphaera leucotricha* (Ell. & Ev.) Salmon)

Powdery mildew is a fungus that attacks the foliage, twigs, blossoms, and fruit of apple and pear. On all these parts it shows first as small grayish or white feltlike patches of fungus growth, which by enlargement may in time entirely cover the part affected. Symptoms that develop later are (1) curling and wrinkling of the leaves, (2) blighting of the blossoms, (3) stunting or killing of the twigs, and (4) stunting and russeting of the fruit. The fungus may become established on fruit either by spore germination on the fruit surface or by growth down the stem from infected twigs.

Mildew russeting on the apple fruit, in its commonest form, has a peculiar lacy or netlike appearance, which distinguishes it rather definitely from russeting caused by spring frosts or spray mixtures (pl. 2, *D*). In the more unusual form of solid patches in which it sometimes occurs it might be mistaken for one or the other of the two injuries just named, except for the fact that there is always more or less of the lacy russeting around the edges of these larger affected areas. Furthermore, the surface of these affected areas is smooth, not roughened as in spray injury.

Powdery mildew attacks the fruit of pear more commonly than the foliage or twigs and produces blackened areas, which become hard and may eventually crack open. On pears it is most serious when they are interplanted with susceptible varieties of apple.

Powdery mildew occurs in nearly all parts of the United States where apples are grown but is usually controlled by the scab sprays applied in eastern orchards. It is generally more of a problem on the Pacific coast than elsewhere. It has been reported as seriously affecting pears of the Flemish, Bartlett, Anjou, and Idaho varieties in Washington and Oregon and is known to occur

sometimes on quince. On the market it is found chiefly on apples grown in Washington, Oregon, and California, the varieties most often affected being Jonathan, Grimes Golden, Winesap, Gravenstein, Yellow Newtown, Ben Davis, and Esopus Spitzenburg.

Control of the disease depends mainly on proper spraying with commercial lime-sulfur or other sulfur sprays.

(See *42, 59, 65.)*

Quince Rust

(See Apple-Cedar and Quince Rusts, p. 10.)

Red Spots

Aphids, particularly the green apple aphid, sometimes cause red spots or specks on yellow or green varieties of apple. These may be confused with the red spots caused by San Jose scale but differ from them in not having a light-colored center.

Similar-appearing red skin spots are particularly common on Yellow Newtown and may occur on other green or yellow apples on the side that has been exposed to the sun. They consist of narrow reddish halos or bands surrounding mechanical injuries or lenticels. If the latter have been ruptured by the growth of the fruit, they are more subject to spotting. Exposure to intense sunlight or penetration of the skin by spray materials also seems to stimulate localized reddening on green varieties or on the green portions of red varieties. Such spots are sometimes mistaken for the effects of San Jose scale, but they can usually be distinguished by their location at lenticels and by the fact that they do not have white or light-colored centers. The spots have been known to develop extensively just before harvest on apples that up to that time were free of them.

Rhizopus Rot

(*Rhizopus* sp., probably *R. nigricans* Ehr. ex Fr.)

Rhizopus rot is seen occasionally on apples and pears on the market, but always on fruit that has been weakened in some way, as, for example, by overmaturity or freezing injury. Affected tissues are soft and watery and have a sour smell.

Rhizopus is a fungus that occurs widely in nature. It is distributed both by contact and by means of its spores. It can be distinguished from blue mold *(Penicillium)* and gray mold *(Botrytis)* by its dark-colored, coarse mold if it is present and by the gray salt-and-pepper appearance resulting from the young (white) and mature (black) fruiting bodies.

Rhizopus rot is not likely to occur on pome fruits if they have been handled carefully throughout the processes of picking, packing, and transporting to market. If it becomes established on these fruits, it can be controlled by keeping the fruit temperature below 50° F.

San Jose Scale Injury

(*Aspidiotus perniciosus* Comst.)

The evidence of injury by San Jose scale most commonly noticed on apples is the presence of small reddish areas about ⅛ inch in diameter (pl. 2, *C*). At the center of each of these reddish

areas is usually a light-colored spot, marking the place occupied by the tiny scale insect before it was rubbed off in the handling of the fruit at harvest or later. In depressed areas, such as the calyx or stem ends, the scales may still be present. The scale covering is gray to grayish brown, less than $\frac{1}{16}$ inch in diameter, with a minute raised nipple at the center, surrounded by a depressed ring. Occasionally a very small black scale, the stage that lives through the winter, is found. Underneath the covering is the scale insect itself, lemon yellow in color; the females are roughly circular in outline, whereas the males are elongate.

Spots suggesting the presence of scale insects may be caused by several other factors. Certain rot infections in the early stages resemble scale spots, even to the red ring, but their centers are brown or black and cannot be rubbed off. A red spot suggesting the scale insect is sometimes caused by green aphids feeding on the fruit, but this has no light-colored center.

The San Jose scale can be controlled by spraying—at any time after the leaves drop in the fall and before the buds open in the spring—with winter-strength lime-sulfur, with oil emulsions, or with miscible oils. The oil sprays are more completely effective and are preferable. For detailed information regarding control measures as well as the life history of the scale, the references cited should be consulted.

(See *47, 48, 93, 101.)*

Scab

(*Venturia inaequalis* (Cke.) Wint.)

OCCURRENCE AND SYMPTOMS

Scab is an orchard disease that affects the leaves, twigs, and fruits of apple. It occurs in all apple-growing sections of the United States where there is appreciable rainfall during the growing season. It is destructive in the cooler parts of the Eastern States, the upper Mississippi Valley, the coastal districts of the northern Pacific Coast States, and the mountainous parts of Virginia, Arkansas, and other Southern States. In most sections east of the Rocky Mountains it is the most destructive of all apple diseases. There is great variation from year to year and from one section to another in the susceptibility of apple varieties to scab. The commercial varieties usually most susceptible are McIntosh, Delicious, Fameuse, Wealthy, Baldwin, Rome Beauty, Rhode Island Greening, and Oldenburg (Duchess).

On the leaves scab appears first on the lower side as olive-colored spots, which have a tendency to spread out irregularly along the veins or the midrib. In the beginning they are slightly darker than the healthy leaf surface; later they turn brown or almost black and take on a velvety appearance. On the upper side the lesions at first have a lighter green color than the healthy surface of the leaf, but later they present the same velvety appearance as on the lower side. Occasionally there is considerable distortion of the surface; toward the end of the season many of the diseased spots die, shrink, and become cracked and ragged. In most sections the disease is rare on the twigs. When it occurs there, the bark becomes blistered and later ruptures in places, so

that affected twigs have a scurfy appearance very much like that of scabby pear twigs.

On the fruit the disease (pl. 1, *A*, *B*) appears as irregularly circular spots, ⅛ to ½ inch in diameter, which have a dark-green to nearly black velvety surface in the early stage. Spots typically dark green and velvety generally show a ragged, papery fringe of skin which has been loosened from the tissues beneath by the growth of the fungus. Later they have a brown, russeted, rough surface with merely a fringe of light to dark green or even black around the margin. The spots are usually most numerous around the calyx end, and when infection is severe they may coalesce and form large, irregular lesions 1 inch or more across. Badly diseased fruits are often misshapen, because of dwarfing on the side where the infection occurs. During several months of storage some lesions enlarge in diameter slightly—rarely by more than ⅛ inch. It may be hard to distinguish lesions that enlarge in storage from those that develop entirely in the orchard.

Scab that develops during cold storage, known as storage scab, looks different from that which develops in the orchard. Usually only a small amount of such scab develops. The greatest development results from late infections in the orchard. Some varieties of apple are susceptible until picked and may become infected late in the season if unusually long rainy periods occur then. The resulting spots may appear soon after the fruit is stored. If inoculation in the orchard is very late, they may appear after several months of storage. Such spots vary in diameter from 1/16 to ¼ inch. They are circular and darker in color than the orchard lesions and have definite borders (pl. 1, *C*). Often the cuticle above the scab spot is not broken and the surface is shiny, although it is usually roughened by the pressure of the mycelium beneath. Dark-brown to black spots, on account of their color, are sometimes confused with blotch. They can be distinguished from it by the facts that no fruiting bodies are developed and the edges of the spots never have the marked feathery, fringed appearance characteristic of the early stages of blotch. On overripe fruit the scab lesions may enlarge rapidly.

CAUSAL FACTORS

Apple scab is caused by the fungus *Venturia inaequalis*. This fungus overwinters mainly on fallen leaves and produces during rainy weather in the spring immense numbers of spores; by means of these the disease is spread to all susceptible parts of apple trees. Although most of the infection, as well as the most severe infection, takes place in the spring about blossoming time, some infection is caused throughout the growing season by spores produced on leaves and fruit that were infected in the spring. The condition most favorable for infection is gentle, steady rain followed by a period of cool, cloudy weather. Heavy rain followed by clearing is much less favorable, the important factor being the length of time the tree remains wet enough to permit spore germination.

The disease does not develop to any marked extent in transit, but it may develop in storage, especially if late infection has occurred in the orchard. Scab lesions afford ready entrance points

for fungi causing such diseases as pink mold rot, fisheye rot, and blue mold rot.

CONTROL MEASURES

Spray schedules for scab vary considerably in different parts of the country. Under ordinary conditions in most sections the disease is controlled by applications of sulfur or ferbam, one of the new organic fungicides. The recommendations of the local agricultural experiment station should be followed in any specific section.

(See *9, 59, 65, 69, 100, 114, 131, 138.*)

Scald

OCCURRENCE, SYMPTOMS, AND EFFECTS

Scald, one of the most serious storage and transit diseases of apple, occurs on fruit grown in all apple-producing sections of the country. No variety is entirely immune, but there is a wide variation in susceptibility. Among the varieties most seriously affected are York Imperial, Grimes Golden, Arkansas (Mammoth Black Twig), Rome Beauty, Rhode Island Greening, Baldwin, Wagener, Stayman, Yellow Newtown, and Winesap.

Scald affects chiefly the skin of the apple and is largely confined to the greener side (pl. 8, *D, E*). Bright-red areas are rarely affected. In mild cases the disease appears as a mere superficial browning of the skin; in more severe cases the entire skin layer is killed (pl. 8, *F*) and sometimes broken down so much that it sloughs off readily from the underlying tissue. In some instances the flesh of the apple becomes dead and brown to a depth of ¼ inch or more and has an appearance much like rotted tissue; but true rots usually spread down into the flesh in more or less conical shape, whereas scald is diffuse.

Apples usually show but little scald while held continuously in cold storage (30° to 32° F.), but fruit that is apparently free from the disease at those temperatures often becomes badly scalded after short exposure to warm air. The higher temperature does not cause the scald; it merely brings out what was already latent in the fruit.

Scald is worse on immature than on mature fruit and also worse on apples from heavily irrigated trees than on those from trees receiving moderate irrigation. It develops more rapidly at high than at low temperatures and is worse in tight than in more open packages. Open stacks with air spaces that permit good circulation of air in the storage room contribute to the prevention of scald, but cannot be relied upon for the control of the disease.

Delaying storage may greatly increase the development of scald, especially if the fruit receives little ventilation during the delay. If immature fruit is adequately ventilated a delay in storing sometimes reduces the development of scald.

CAUSAL FACTORS

Scald is believed to be caused by accumulation within the apple tissues of certain gases that are produced by the apples themselves as a result of their respiratory activity. These gases can be at

least partly removed by aeration and ventilation, but removal is difficult to accomplish in closed packages under the usual storage conditions. The injurious gases can be absorbed by oils, a characteristic which is the basis for the most practical method of scald control now available—that of packing the apples in oiled (not waxed) paper.

CONTROL MEASURES

Oiled wrappers should be used on apples of susceptible varieties in packed boxes, and shredded oiled paper should be scattered among apples in boxes and baskets that are faced and filled. For each bushel of apples about ½ pound of shredded paper is required. It must be well distributed in the package, with practically every apple more or less in contact with the paper. Oiled wrappers should carry at least ¼ gram of oil per sheet and both wrappers and shredded oiled paper should have at least 15 percent of their finished weight in odorless, tasteless mineral oil. Eighteen percent or more of oil is desirable if lightweight paper is to be used on the more susceptible varieties of apples. The apples should be packed in the oiled paper as soon as possible after picking. Unless this is done within 3 or 4 weeks after the fruit is put in cold storage, it is not usually possible to overcome the tendency to scald.

(See *12, 27, 43, 44, 51, 59, 105, 106, 109, 135, 136.*)

Side Rot

(*Phialophora malorum* (Kidd & Beaum.) McColloch)

Side rot, a disease of apple and pear, was listed in the original version of this publication as sporotrichum rot and was described with the group classed as bull's-eye rots. Since then the causal fungus was reclassified *(80)*. The rot produced by this fungus on apples and pears is quite distinct from bull's-eye rot in most respects and is therefore described separately.

OCCURRENCE AND SYMPTOMS

Side rot has been reported on pears grown in the northwestern part of the United States and on apples grown there and in Indiana, Virginia, West Virginia, and Maryland. It has been observed on a wide range of varieties, but more frequently on Winesap and Delicious than other varieties.

Typical lesions are oval, but often they have slightly irregular margins. They are usually less than 1 inch in diameter, are slightly sunken, and have a dull appearance (pl. 7, *E, F*). The color of the lesions varies from brown with a pale center to dark brown. The surface is frequently cracked, but when it is not it breaks with a pop under slight pressure. The texture of the decayed tissue when the rot is active is wet and slimy. It separates cleanly from the healthy tissue, leaving a saucer-shaped cavity usually about 1/16 to ¼ inch deep. In certain cases where the rot is less active, especially where the surface has been broken, the texture is dry and spongy. The rot is tender and is not firm, giving readily under pressure.

The tendency of side rot lesions to have pale centers is the reason that it is sometimes confused with bull's-eye rot. Although

there is considerable variation, the lesions of bull's-eye rot are usually larger and paler. If the bull's-eye rot spots are large, the causal fungus may be fruiting on them. They are fairly firm and do not separate readily from the healthy tissue; in cross section bull's-eye rot is found to penetrate toward the core in a U-shaped pattern.

CAUSAL FACTORS

The fungus *Phialophora malorum,* which causes side rot of apple, is primarily a saprophyte living in surface soil and upon the bark and in cankerous woody tissues of apple trees. Apples become contaminated while on the trees, and under favorable conditions the fungus develops and causes serious and unpredictable losses in fruit in storage. Most lesions occurring on apples appear to develop around lenticels, but it is difficult to determine in many cases whether the point of entrance was a lenticel or a cuticular crack. The fungus enters also through insect injuries and mechanical punctures. Side rot may appear as early as January in cold storage, developing on bruised areas. It does not become serious on unbruised tissues until later in the storage season; it may be found in considerable abundance at the time the fruit is removed from cold storage. The size and number of the lesions and the number of fruits infected may be expected to increase rapidly after the fruit has been out of storage for a few days. The development of decay in storage and on the market is the result of spores that are present on the apples at harvest.

CONTROL MEASURES

The causal fungus has difficulty in establishing itself and causing decay except in bruised tissue and in tissue weakened to a certain point by natural aging. At present no satisfactory control measures such as spraying or disinfection have been found. The rot can be greatly reduced, however, through careful handling of the fruit to prevent undue bruising and mechanical injury and through prompt storing and cooling down to cold-storage temperatures.

The rot has been known to develop much more seriously in fruits in some orchards than in others. The difference is thought to be associated with the degree of maturity of the fruit when harvested and with the rate at which the fruit ripens and weakens in cold storage. Where fruit is definitely known to develop an unusual amount of side rot in storage, it would probably be well to market it earlier than that which remains sound longer.

(See *80.)*

Skin and Flesh Cracking

Under this general heading are included cracking in certain varieties of apples due to weather conditions and also skin cracking due to washing injuries in the preparation of the fruit for packing.

RAIN CRACKING

Rain cracking occurs most seriously on Stayman, Wealthy, and York Imperial apples grown in humid districts. In the same lo-

cality Stayman is much more susceptible to cracking than York Imperial, and the deep, extensive cracking often causes serious losses. Rain cracking develops after periods of cloudy, rainy weather, when the rates of evaporation and transpiration are very low. During such periods apples may absorb rain water through the skin and this in addition to the supply from the roots permits unusually rapid enlargement of the fleshy cells. The internal pressure from the enlarging cells against the surface of the fruit creates a strain that results in cracking. The side of the apple exposed to the sun, especially if any abnormal condition such as sunburn or spray injury is present, is the most susceptible to cracking.

Cracking is similar on Wealthy and Stayman apples. The condition occurs so frequently and so seriously on the latter variety that it is often termed "Stayman cracking." Cracking occurs chiefly on the cheeks of the fruit in the form of irregular breaks in the skin and underlying flesh. The breaks vary from almost invisible short slits to cracks ½ inch or more deep that may extend almost completely around the apple. Late in the growing season cracks may originate near the stem and extend out over the cheek in more or less straight lines toward the calyx. Cracks around the calyx basin are rare. The exposed flesh gradually becomes discolored and decay follows, often while the fruit is on the tree.

In York skin crack, the cracks are small and tend to run in a latitudinal direction on the cheek of the fruit. If there is a worm sting, hail scar, or other old injury on the fruit the cracks usually run around this center, more or less in rings.

The cracks may make a wavy line and vary from being barely discernible to being open as much as 1/16 inch. At first there is no discoloration except possibly a slight russeting, but as the cracks become older they turn almost black. As the underlying tissues dry out the skin is pulled loose and becomes bleached or grayish. In the late stages of York skin crack the cracks are very numerous on the affected parts of the apple and are likely to be accompanied by wilting.

York skin crack seems to occur on fruit grown on trees of comparatively low vitality or affected by drought during the growing season. It appears to be worse on light-crop trees than on those bearing heavy crops. There is evidence that the severity of the cracking is increased by late rains that cause the apples to swell rapidly and by late spraying with lead arsenate.

Apples affected with York skin crack are more mature than normal fruit and should be packed and handled separately on this account as well as because it is practically impossible to sort out all affected apples if they are mixed with the general crop. The cracked skin of these apples renders them susceptible to decay in much the same way as any mechanical injury which breaks the skin.

HEAT CRACKING

Heat cracking may be produced by hot washing treatments for removal of spray residues, particularly if dipping tanks or other home-made devices are used. It occurs when a cold, turgid apple is subjected to too long exposure in heated washing solutions. A

45-second exposure to a temperature of 110° F. is about as much as apples of most varieties will stand without cracking. The York Imperial seems to be especially subject to this injury and should be handled accordingly, either by reducing the temperature of the washing solution or by shortening the exposure. It is generally not necessary to use heated solutions, unless unusual spray practices have been followed.

Heat cracking is characterized by numerous fine cracks running latitudinally around the apple, especially in the region around the calyx, and often extending out onto the cheek. The cracks develop within 24 hours after the washing treatment as fine white lines that are clearly visible. As the tissues begin to dry out the cracks widen until they assume the general appearance of advanced stages of York skin crack. However, in heat cracking the regularity of form and location is more pronounced than in the other type. Like apples affected with other forms of skin cracking that expose the underlying flesh, heat-cracked apples are subject to early wilting and decay. Apples are somewhat more susceptible to this type of injury at the time of harvest than after being kept for several weeks.

(See *41, 46, 121, 130.)*

HYDROCHLORIC ACID INJURY AND SKIN CRACKING

(See Injury by Hydrochloric Acid, p. 24.)

Soft Scald

Soft scald is a nonparasitic disease of apple that is sporadic in its occurrence even on highly susceptible varieties, but it sometimes causes heavy losses. It occurs most frequently on Jonathan, McIntosh, Rome Beauty, and Wealthy, but it is occasionally found on Stayman, Winesap, Winter Banana, Baldwin, Wagener, Grimes Golden, Northern Spy, and other varieties.

The disease is characterized by peculiar patches and ribbonlike areas of brown tissue on the surface of the apple and by a sharp line of demarcation between the diseased and the healthy tissue (pl. 8, *G, H*). Sometimes only the skin of the apple is affected, but more often the browning extends into the flesh for ⅛ inch or more. Black spots on areas injured by soft scald are usually caused by secondary infection by *Cladosporium* or *Alternaria.*

Soft scald is apparently due to abnormal respiratory conditions in the apple. It is much more likely to develop at temperatures that border on the freezing point of apples than at those a few degrees higher and is greatly increased by delay in placing the fruit in storage.

Oiled paper does not control soft scald. Holding the apples in an atmosphere containing 20 to 30 percent of carbon dioxide for 2 days during the period of cooling has largely or entirely prevented the later development of soft scald, but this treatment has not become an established practice.

(See *12, 16, 50, 59, 105, 106, 114.)*

Soggy Break-Down

Soggy break-down is a nonparasitic disease of apple that sometimes has been included under internal break-down, but it appears

to be distinct as to both characteristics and cause. Jonathan, Northwestern Greening, Grimes Golden, Wealthy, and Golden Delicious are very susceptible to the disease.

Soggy break-down is first evident as light-brown areas in the cortical region of the apple. The discoloration may continue until a large part of the cortex is involved and a complete ring of soft brown tissues has formed (pl. 9, *A*, *B*). The affected flesh is sharply delimited from the normal and is typically moist and soggy, although sometimes it becomes mealy when the disease is in an advanced stage. Adjacent sound tissue usually has a characteristic fermented taste. The skin of the apple may appear normal except in the later stages of the disease, but affected fruit can be detected by a characteristic sponginess due to the underlying soft tissue.

Soggy break-down is akin to soft scald in the conditions responsible for its occurrence. It is more prevalent on apples stored at 30° F. than on those held at 32° and is usually completely prevented by storage at 36° to 40°. It is generally increased greatly by delaying storage.

Holding apples in an atmosphere containing 20 to 30 percent of carbon dioxide for 2 days during the cooling period has largely or entirely prevented the later development of soggy break-down.

(See *16, 17, 104, 107, 108, 109.)*

Sooty Blotch

(*Gloeodes pomigena* (Schw.) Colby)

Sooty blotch is marked by sooty patches or spots, very irregular in size and shape, which may occur on any part of an apple (pl. 1, *F*). They are easily removed by scraping or by moistening and wiping the apple. On Kieffer pears the blotches are often surrounded by a russet zone. The causal fungus does not cause decay or even browning of the tissues under the spots, but affected fruits are sometimes badly wilted. The chief loss is due to blemishing by the fungus and consequent reduction in the market value of the fruit.

Sooty blotch is common throughout the central and eastern apple-growing sections of the United States, but is rare in the Northwest. All late-summer and winter varieties may be affected.

The disease does not develop or spread in transit or storage and is of minor importance on the market. It is controlled by spraying with bordeaux mixture or ferbam as recommended by the local agricultural experiment station.

(See *59, 65, 114.)*

Spongy Dry Rot

(*Colletotrichum fructus* (F. L. Stevens & Hall) Sacc.)

Spongy dry rot has been reported to cause loss in North Carolina, Massachusetts, New York, West Virginia, Pennsylvania, and Indiana, usually on fallen fruits. It is rare on the market.

In early stages the disease appears as small black spots scattered over the surface of the fruit. Later, as these enlarge, they coalesce and form black sunken areas, ½ to 1 inch or even more in diameter, which eventually become roughened by the fruiting bodies of the fungus. Affected areas resemble those produced

by the black rot fungus, but they are firmer, drier, and more uniformly black throughout.

The causal fungus grows very slowly at low temperatures and apparently cannot penetrate the uninjured skin of apples.

(See *12, 59, 65, 127.*)

Spray Injury

There are several types of spray injury to the skin of apples. Some of them can be readily attributed to a particular spray material, whereas others have various possible causes.

Russeting is the most common form of spray injury. When it is produced by bordeaux mixture the skin is often decidedly rough, showing evidence of extreme injury. When caused by arsenicals, lime-sulfur, or oils, the injury is likely to be less serious and usually shows finer lines and markings.

Russeting may be due to causes other than spraying, but the effects are usually somewhat different. Spring frosts often produce russeting, but the injury is usually found in definite bands and lines around the fruit. Mild forms of russeting may be due to cold spring rains and other unfavorable weather conditions and are sometimes difficult to distinguish from the milder cases of spray injury. External cork caused by boron deficiency occurs as rough, corky areas of irregular shape on any part of the apple.

Bordeaux russeting is most likely to result from applications of bordeaux mixture early in the season (pl. 3, *A*). Late applications sometimes cause injury in the form of small red spots, especially on green or yellow varieties such as Yellow Newtown. Varieties most susceptible to roughening and russeting by bordeaux mixture are Ben Davis, Grimes Golden, and Golden Delicious.

Sulfur injury from lime-sulfur or other sulfur fungicides is likely to be worse under high-temperature conditions. Mild cases often take the form of bronzing or browning of the area most exposed to the sun, whereas severe injury results in the formation of hard, leathery grayish areas, which may or may not slough off (pl. 3, *B*); in the most severe cases there is also cracking of the affected area of the fruit. The Grimes Golden and Golden Delicious varieties are especially susceptible to injury by lime-sulfur sprays.

In addition to russeting, arsenicals are responsible for another form of injury to the fruit known as calyx injury, or blossom-end injury. This appears as a dark-brown or nearly black area around the calyx of the apple and often furnishes a place of entry for the black rot fungus or other decay organisms.

Oil sprays cause various types of injury on apples. One of the most common is very similar to the calyx injury that results from arsenical sprays. In other cases oil injury is exhibited by russeting and deformation of the apple, which becomes gnarled and roughened. Injury from oil sprays is much more likely to occur on trees suffering from drought or on those low in vigor from other causes. Spraying should be avoided during periods of high temperature (90° F. or above), and care must be exercised at all times to use an acceptable type of oil as well as to have it properly emulsified.

(See *36, 42, 81.*)

Stigmonose (Insect Punctures)

"Stigmonose" is a general name used to designate certain surface depressions and distortions of fruit, conditions which may be caused by a wide variety of insects, chiefly sucking ones of the group which includes the plant bugs and aphids. Growth of the flesh of the fruit at the point where the feeding punctures occur is more or less retarded, and characteristic depressions form (pl. 4, *G*). Underneath these depressions are often found small, roughly hemispherical masses of corky brown tissue (pl. 4, *H*). Badly affected fruits may be considerably distorted. The injury to the flesh bears some resemblance to bitter pit. However, the masses of cork are always near the surface, whereas bitter pit spots may be either near the surface or deep within the flesh and in either case are closely connected with the water-conducting system of the apple. Stigmonose can occur anywhere on the surface of the fruit, whereas bitter pit is usually confined to the calyx half.

An important cause of stigmonose in the Northwest and elsewhere is the tarnished plant bug *(Lygus oblineatus* (Say)). The bugs feed on apples, pears, and other fruits. On emerging from hibernation in early spring, they feed on the buds, flowers, and newly set fruits. Although most of the injured fruits drop, some of them remain on the tree and may become very much distorted. In the Northwest, injury is most common on Delicious apples and on Anjou, Bosc, and Bartlett pears. Except for a brief period in the spring, the bugs live on various herbaceous plants. Clean culture helps to eliminate the favored plants on which the bugs breed, but this cannot be recommended where cover crops are considered essential to the orchard-management program. For many years no satisfactory method of controlling the tarnished plant bug was known. Recently several investigators obtained very satisfactory control in peach orchards by spraying with DDT just after the petals had fallen. Presumably such treatment would be effective in protecting apples and pears from injury by this pest. Exact timing of the applications, however, remains to be worked out.

In the northeastern part of the United States, apple red bugs *(Heterocordylus malinus* Reut. and *Lygidea mendax* Reut.) are responsible for a great deal of injury of the stigmonose type. These bugs cause less distortion of the fruits than the tarnished plant bug. The newly hatched red bugs, which appear on the shoots of the apple trees about blooming time, can be controlled by application of nicotine sulfate in either the pink or the calyx spray, depending on the time when the insects first appear.

The boxelder bug *(Leptocoris trivittatus* (Say)) also occasionally causes stigmonose. Boxelder bugs, which are larger than tarnished plant bugs and marked with red, feed in clusters on maturing fruit. They breed chiefly on boxelder and when full-grown migrate to nearby apple trees. Replacement of boxelder trees in the vicinity of orchards with other kinds of shade trees will prevent injury from this cause.

The apple maggot, or railroad worm, may cause small dimple-like spots in the surface of the apple, as described on page 9;

when the fruit is cut open, small winding tunnels extending deep into the flesh are usually found (pl. 15, *A*).

The rosy apple aphid *(Anuraphis roseus* Baker) also causes a form of stigmonose. The insects feed on the newly formed, small apples and cause apples to be very much stunted, knotty, distorted, usually with a characteristic puckering of the surface around the calyx end (pl. 2, *H*). The rosy apple aphid can be controlled by any one of several different treatments applied during the dormant or the "delayed dormant" period. Several of the so-called DN compounds and tar-distillate oils are effective in killing the aphid eggs.

Since these materials are likely to cause injury to growing plant tissue, the applications must be completed before the buds start to swell. Rosy apple aphids may be controlled also by application of a "delayed dormant" spray at the time when the bud tips show green. The most effective spray consists of ¾ to 1 pint of nicotine sulfate (40-percent nicotine) in 100 gallons of water. The nicotine sulfate solution may be added to concentrated lime-sulfur if it is being used at this time for control of San Jose scale. The oil sprays, which have to a considerable extent replaced lime-sulfur for dormant spraying, are less dependable for aphid control, but with the addition of nicotine they are usually effective when applied in the "delayed dormant" period.

Current recommendations of the Bureau of Entomology and Plant Quarantine or of State agricultural experiment stations should be used as a guide in working out a control program for this pest.

Sunburn, Sunscald, and Delayed Sunscald

"Sunburn" is the name applied to the condition of apples the skin of which has become golden or bronzed on the side that has been most exposed to the sun. This abnormal color detracts from the appearance of the fruit, but normally the skin is not killed and the tissues show no sign of break-down (pl. 3, *E*).

True sunscald is found occasionally as white or tan-colored spots, especially on apples that after being protected for some time have been suddenly exposed to the sun. In severe cases, as when an apple lying on the ground has been really scalded, the skin and flesh present the appearance of having been held to a flame (pl. 3, *F*). Such apples are, of course, rare on the market.

Occasionally in storage apples are found with brown, somewhat shriveled and sunken areas that were not in evidence when the fruit was stored. Such conditions developing after harvest are known as delayed sunscald and afford entrance points for decay organisms such as the fungus causing alternaria rot.

(See *14.*)

Washing Injuries

(See Chemical Injuries, p. 23.)

Water Core

Water core occurs in practically all apple-producing sections of the United States, but it is of greatest importance in those hav-

ing an arid or semiarid climate. Among the most susceptible varieties are Yellow Transparent, Rambo, Tompkins King, Jonathan, Delicious, Stayman, Winter Banana, Arkansas (Mammoth Black Twig), and Winesap. In the Northwest the last-named variety is more often affected than any other.

Water core is a nonparasitic disease characterized by water-soaked regions in the flesh of the apple. When water core is severe, these areas are hard and glossy. The disease is more commonly found near the core and around the primary vascular bundles, but it may occur in any part of the apple or may involve the whole of it (pl. 10, *G*, *H*). When only the core area is involved it is impossible to detect the disease without cutting the fruit (pl. 10, *F*). Visible water core is frequently associated with sunburn.

Water core is particularly bad in sections where heat and sunlight are intense. High temperatures at the time the apples are approaching maturity are especially favorable to its development. The disease is most likely to occur in fruit that is freely exposed to the sun. It often increases rapidly as apples become overmature. Apple tissues affected with water core are distinctly different in both texture and location from the soft, water-soaked tissues adjacent to spots bruised while the apples were frozen.

Water core not only does not develop or spread in transit or storage, but in certain varieties such as Yellow Newtown and Winesap it may actually disappear after a few months' storage, particularly if originally present in only a mild form. When large portions of the flesh are affected, especially in soft-textured varieties like Jonathan, Delicious, Stayman, and Rome Beauty, there is danger of subsequent break-down and prompt disposal of the fruit is advisable.

Control of the disease is mainly by picking fruit before extensive water core develops. Near harvesttime growers should examine the fruit for presence of water core, particularly fruit well exposed on the southwest side of the tree, and start picking if appreciable water core is developing.

(See *12, 15, 45, 59, 65, 114.)*

PEARS

Ammonia Injury

Exposure to ammonia fumes may cause injury to pears. The trouble is first evident as reddish-brown rings around lenticels and at abrasions. Upon removal from an atmosphere containing ammonia the skin color soon changes to black (pl. 11, *F*). In mild cases the injury does not extend beyond the tissue immediately beneath the epidermis. With more severe exposure the lenticel spots may become much enlarged and finally coalesce and the discoloration may extend deep into the flesh.

The presence of moisture is favorable to ammonia injury; pears with moist surfaces are more susceptible than those that are badly wilted or those that have dry surfaces. Immature pears have been found more susceptible than mature ones.

(See *68, 110.)*

Black End

OCCURRENCE AND SYMPTOMS

Black end, or hard end, of pear occurs in many of the pear-growing sections of the Pacific Coast States. The disease is frequently found on the Bartlett variety. Anjou, Winter Nelis, Comice, Easter Beurre, Clairgeau, and probably other varieties also are affected. Black end fruits are culled out rather carefully during grading and packing, and consequently severe forms of the trouble are not often seen on the market.

The first symptoms of black end become evident when the fruit is a third to half grown as an apparent protrusion of the calyx due to the retarded development of the tissues around it. Another symptom is the enlargement of the calyx opening. At this time the epidermis over the affected portion appears tight and shiny. As the disease progresses, the calyx lobes turn black, the tissues surrounding the calyx opening become hard, and a brownish discoloration begins to form. This discoloration may appear at first in separate spots, which later coalesce; in other instances a large area may be completely and uniformly discolored from the beginning. The final color of the affected tissues is black. Cracks sometimes 1 inch or more in length may appear in the blackened areas. On many specimens the discoloration is confined to an area extending from the calyx for only ¼ to ½ inch (pl. 12, *A*, *B*); on some it covers half the surface of the fruit.

The discoloration usually does not extend deep into the flesh and sometimes affects only the skin. Less seriously affected fruit may not be discolored at all but have hard, gritty flesh around the calyx and a pointed or peaked appearance that characterizes typical black end fruits. The affected part of a fruit is likely to be lighter green in color than healthy fruit, until it is fully ripe. Mildly affected fruits are more common in market channels than fruits severely affected with black end, since the latter can be more completely eliminated in grading. Black end does not develop or spread in storage or in transit.

CAUSE

Black end of pear is a psysiological disease; that is, no bacteria or fungi are found associated with it. The disease is found on fruit from trees grown on Japanese *(Pyrus pyrifolia* (Burm.) Nakai; synonym: *P. serotina* Rehd.) and certain other oriental rootstocks; hence the conclusion has been drawn that this kind of rootstock is in some way the principal cause of the disease. There is strong evidence that excessive subsoil moisture in the spring and other abnormal moisture conditions in the soil or a shallow-lying hardpan favor the development of black end on fruit from trees on these rootstocks.

CONTROL MEASURES

Control measures that have been suggested are (1) use of French rootstock *(Pyrus communis)* and (2) ample subsoil drainage and ample soil moisture.

(See *33, 63, 96, 139.)*

Black Rot

(See Apples, Black Rot, p. 14; pl. 5, *G*.)

Black Spot

(See Quinces, Black Spot, p. 65; pl. 11, *B*, *C*.)

Blue Mold Rot

(*Penicillium expansum* and possibly other species of *Penicillium*)

Blue mold rot of pear (pl. 13, *A*, *B*) usually has the same symptoms as the rot of the same name on apple. There is a form, however, known as pinhole rot, which in its early stages appears as numerous minute spots of decay scattered over the surface of the fruit. Infection apparently takes place at lenticels in the skin. As the disease progresses the spots increase in size and finally coalesce, so that eventually the fruit becomes entirely decomposed.

Pinhole rot occurs on both washed and unwashed fruit. It is most serious on the Winter Nelis variety, but other varieties are sometimes attacked. Pinhole rot is most severe on fruit that is ripened slowly; hence it is probably best controlled by maintaining the fruit in a hard, green condition while in storage and ripening it quickly upon removal.

(See *56*, *59*.)

Brown Rot

(See Apples, Brown Rot, p. 20; pls. 5, *H*, and 13, *G*.)

Bruising

(See Silicate Injury, p. 63; pl. 14, *G*, *H*.)

Bull's-Eye Rot

The name "bull's-eye rot" is applied to two rots of pear just as done for those of apple. (See also Apples, Bull's-Eye Rot, p. 22; pl. 13, *E*.)

Core Break-Down

Core break-down seems to be more serious in districts having cool growing seasons than in hotter ones, but it occurs in all pear-growing sections. Most varieties of pears are subject to the disease. Clairgeau, Clapp Favorite, Early Harvest, Guyot, Jargonnelle, Le Conte, Madeleine, and Sudduth have been reported susceptible under New York conditions. Of the varieties grown in the Northwest, Bartlett, Bosc, Comice, and Clapp Favorite have been found most susceptible.

Various names have been applied to the disease by different authors; among these are internal break-down, core rot, and brown heart. As the names imply, the disease is characterized by softening and browning of tissues in the region of the core (pl. 14, *A*, *B*). The break-down may be closely confined to the core or may extend to surrounding flesh. Sometimes the softening is most pronounced in a zone about halfway between the center and the outside of the pear. In the early stage the affected tissues are soft and watery, and in any stage they have a disagreeable,

sickening odor. In late stages the color becomes brownish or black, and in severe cases rapid break-down and browning of the entire fruit occur. The internal condition is often associated with a discoloration of the skin resembling scald.

Core break-down is classed as a market or storage disease of pear, but its time of occurrence depends largely upon the maturity of the fruit at the time of picking. Tests have shown that fruit harvested after its best picking time is much more likely to become seriously affected in storage or on the market.

(See *52, 53, 86, 103.)*

Freezing Injury

When pears of the Bartlett and Anjou varieties are exposed for long periods to temperatures only slightly below freezing, they develop a condition that is fairly definite in its symptoms. In all cases the affected specimens have a glassy, water-soaked appearance externally (pl. 14, *E*). When such fruits are cut, the water-soaked condition is seen to be confined to certain portions of the flesh. Usually it is found just beneath the skin and involves several layers of cells. It may occur also within the core area. The remaining flesh is usually dry and pithy (pl. 14, *F*) ; and in cases of severe injury it may be badly cracked, so that there are numerous open spaces. Freezing injury should not be confused with old-age break-down (pl. 14, *C*).

Pears showing the symptoms just described often remain in an unchanged state for several weeks. They seem to be rather resistant to decay and do not undergo normal break-down from overmaturity, but they are inedible and have no commercial value.

The injury has been found to develop slightly in 4 weeks and to become severe in 6 weeks in pears held at a temperature of 27° F., which is slightly below their freezing point.

(See *55.)*

Gray Mold Rot

Gray mold rot (pl. 13, *C, D*) is one of the most serious storage diseases of pear. The term "gray mold" is descriptive of the gray mycelium that appears on the fruit in the late stages of decay. The disease is also known as cluster rot and as nest rot because a large number of affected fruits are frequently found at one location in the package. The fungus mycelium grows from one pear to another in such a manner that it holds the rotting fruits together. It is often possible by careful examination to trace the infection of large clusters of pears to a single initially infected pear. Gray mold rot is darker brown than blue mold rot, and the affected tissue is relatively much firmer. It usually has a sour smell.

The causal fungi *(Botrytis* spp.) are widely distributed and live upon a large number of hosts. They are present on decaying matter in the orchard, a circumstance that probably is responsible for much of the infection found in stored fruit. Infection frequently takes place through the stem, starting at the free end. Diseased stems become soft and spongy and in advanced stages of the decay can be crumbled between the fingers. When pears for storage are not packed immediately after picking, special

care should be exercised to sort out any with partly decayed stems or to cut these stems off below the affected part. Prompt cooling of the fruit reduces the seriousness of the disease, but the causal fungi can continue to grow and produce decay at the usual cold-storage temperatures.

Good packing-house sanitation and careful handling of fruit to prevent abrasions and bruises are of value in preventing development of the disease in storage. The most practical method of preventing spread of the rot from one fruit to another is use of copper-treated wrappers. Such wrappers are generally used at the present time. Wrappers treated with soluble copper compounds such as copper sulfate may cause injury if the pears are wet when packed. This injury is exhibited as irregularly shaped black spots scattered over the surface of the fruit (pl. 11, *E*). At present commercial wrappers are usually impregnated with a more stable copper compound, which does not cause injury.

Recently sodium chloro-2-phenylphenate as a disinfecting wash for apples and pears has been used on a commercial scale in certain producing sections of the Northwest. Treated pears show a substantial reduction in gray mold rot, as well as some reduction in other kinds of decay. In packing houses using the treatment, precautions are necessary to protect workers from excessive contact with the solution or with fumes from the washing tank.

The fruit is usually uninjured by the treatment, but injury occasionally occurs. The cause of injury cannot always be determined. Some possible causes are concentration of the chemical resulting from evaporation of drops of the solution adhering to the fruit, insufficient wax on the fruit, and reduced alkalinity of the treating solution. There is indication that injury may result when the reaction of the treating solution is less than pH 8.

On pears the injured areas may occur anywhere on the fruit. They are black and are not sunken at first, but they may eventually become sunken (pl. 11, *G, H*). On apples the injury resembles soft scald somewhat. The affected areas are medium brown. They lack the large patterns with sharp margins characteristic of soft scald and usually are not sunken. Injury occurs in the calyx basin more frequently than elsewhere (pl. 5, *D*).

(See *29, 30, 38, 56, 75, 76.*)

Pear Leaf Blister Mite Injury

(*Eriophyes pyri* (Pgst.))

occurrence and symptoms

Two types of injury by the pear leaf blister mite may be found on pears and also on apples: A diffuse russeting, usually most marked at the calyx end, and irregularly shaped, depressed, russeted spots ⅛ to ½ inch in diameter, most of which are eventually surrounded by a zone of almost decolorized skin (pl. 11, *D*). Severely infested fruit may be considerably distorted. This mite is widely distributed over the United States, but on the market the injury is seen most often on fruit grown in Pacific Coast States.

CAUSE

Blister mites are microscopic in size and elongate in shape and have only two pairs of legs. They hibernate under bud scales and appear on the foliage as soon as it unfolds. Their activities result in the development of small blisterlike swellings, which later become brown and dry, giving an appearance of spotting similar to that caused by leaf spot fungi. Although the most serious damage is to the foliage, blossoms and young fruit are attacked.

CONTROL MEASURES

The blister mite can be controlled by thorough spraying during the dormant period with winter-strength lime-sulfur, as for San Jose scale. Oil sprays applied during the dormant season are less satisfactory, although fairly good results have been obtained by using them in warm periods in the spring after the buds have begun to swell.

(See *93, 101.*)

Pear Psylla Injury

(*Psylla pyricola* Foerst.)

Pears injured by the pear psylla are black as a result of the growth of a black fungus on the honeydew produced by the insects, which also cause serious injury to foliage and young growth. The psylla is a tiny cicadalike insect, about $\frac{1}{10}$ inch long when full-grown. Adults hibernate in cracks in the bark of tree trunks and limbs, under bark scales, or under trash on the ground in and near orchards and migrate to the trees on the very first warm days of spring. Applications of 3-percent lubricating-oil emulsion at this time have given very satisfactory results. They kill many of the adult flies, and the film of oil on the bark appears to have a great deal of residual value, reducing the number of eggs laid and killing a high percentage of the young psyllas that hatch. Nymphs of the first brood congregate mostly in the axils of young leaves and fruits and may be treated with a nicotine-soap spray applied just after the blossoms fall.

Pink Mold Rot

(See Apples, Pink Mold Rot, p. 42; pl. 7, *B.*)

Powdery Mildew

(See Apples, Powdery Mildew, p. 43; pl. 2, *D.*)

Rhizopus Rot

(See Apples, Rhizopus Rot, p. 44; pl. 13, *H.*)

San Jose Scale Injury

(See Apples, San Jose Scale Injury, p. 44; pl. 2, *C.*)

Scab

(*Venturia pyrina* Aderh.)

Scab on pear (pl. 11, *A*) is similar to the disease of the same name on apple, although the two are caused by different species of the fungus *Venturia.* Pear scab usually occurs as larger, rougher

spots on the fruit than are common for apple scab and occurs more frequently on the twigs than apple scab. On Seckel and possibly other varieties very small scab spots that may be mistaken for other blemishes if not carefully examined sometimes occur.

Pear scab is an important disease in many of the commercial-pear-growing sections. It can be controlled by the treatment recommended for apple scab (p. 47).

(See *59, 65.*)

Scald

COMMON FORM

A brown to black discoloration of the skin of Bartlett, Bosc, and some other commercial varieties of pears is known as scald. The disease is apparently much less common on the market than apple scald, and it is not understood so well. Although there is no definite proof that it is caused in the same way as apple scald (p. 47), certain investigations have shown that, like apple scald, it is worse on immature than on mature fruit and is most likely to occur when ventilation is poor. In early stages the disease is entirely superficial, but it progresses rapidly into the flesh at moderate or high temperatures. In late stages the skin becomes weakened and sloughs off readily, so that scald is very likely to be followed by blue mold rot and other decays.

The taste and odor of affected fruit are characteristically disagreeable and sickening even before discoloration appears. The ordinary form of scald has been found to develop on pears of the Bartlett variety in 30 to 35 days at 43° F. and in 70 to 80 days at 36°, and it generally does not develop at all at 31° during the ordinary storage period for this variety. On other commercial varieties stored at 32° scald does not usually develop to any serious extent until near the end of their maximum storage period. Oiled paper used as for apple scald has not given control of this common form on pears.

(See *86, 103.*)

ANJOU SCALD

On Anjou pears scald causes a brown or dark discoloration (pl. 14, *D*), which detracts materially from the appearance of the fruit, but it is not accompanied by sloughing of the skin or by unpleasant odors as in the common form and does not impair eating quality. The condition occurs (1) on both washed and unwashed fruit, (2) on precooled fruit and on fruit that has not been precooled, and (3) on fruit held constantly at 32° F., as well as on fruit held for various lengths of time at other temperatures.

The disease may be controlled by wrapping in oiled paper, so that in this respect Anjou scald seems to be similar to apple scald.

(See *54, 56.*)

Side Rot

Side rot, caused by *Phialophora malorum,* occurs on pears grown in the Pacific Northwest, and at times it has been serious. The decay spots are relatively small and dark brown to black (pl. 13, *F*). They never have pale centers like those of bull's-eye rot on pear. (See also Apples, Side Rot, p. 48.)

Silicate Injury

On certain varieties of pears, both on the market and in cold storage, a brown spotting that is different in some respects from that caused by rubbing or bruising was a problem some years ago. It was often found on pears that had been in contact with corrugated-paper lining the boxes or with excelsior-filled pads used in boxes to prevent bruising.

In some of the corrugated paper used for lining pear boxes, sodium silicate has been used as a binder to hold the corrugated and the flat sheet together. Some grades of silicate contain a small percentage of free alkali, and there is abundant evidence that this is the constituent that caused the injury. Moisture was necessary, and in many instances it seemed to be present in sufficient amounts within boxes packed with pears to cause some of the alkali contained in the paper liners to go into solution and produce injury.

The spotting was brown and usually only superficial and was most pronounced on russeted areas of the skin. It sometimes occurred in bands crosswise of the fruit, corresponding to the corrugations in the paper liner, but usually it appeared merely as irregularly shaped brown spots ¼ to 1 inch in diameter. Varieties on which it was found are Winter Nelis, Bosc, and P. Barry, all of which showed more or less russeting. It was not found on smooth-skinned pears, although a dark discoloration on Anjou pears, the result of pressure or rubbing against the paper liner, the box, or other pears, was sometimes confused with it.

Silicate injury seems to have no effect on the keeping quality of the fruit. The spotting can be avoided by using liners that do not contain free alkali from sodium silicate or any other source. Apparently the conditions causing silicate injury have been corrected.

(See *117.*)

Sooty Blotch

(See Apples, Sooty Blotch, p. 52.)

Spray Injury

(See Apples, Spray Injury, p. 53.)

Stigmonose (Insect Punctures)

(See Apples, Stigmonose (Insect Punctures), p. 54; pl. 4, *G*, *H*.)

Stony Pit, Corky Spot, and Boron-Deficiency Pitting

Three kinds of pits found on pears are at first sight so similar in appearance that they are often confused. These are stony pit, corky spot, and pits resulting from boron deficiency.

Stony pit is common in pears of the Bosc variety, and major commercial losses caused by it appear to be limited to that variety. It is also found in pears of the varieties Winter Nelis, Anjou, Hardy, and Forelle; but losses in these are generally negligible. Stony pit is widely distributed, probably wherever the Bosc variety is grown. In the United States it is not known to

occur outside the Pacific coast area. It has been reported from British Columbia, Australia, and southern Africa, and it probably occurs in England.

Stony pit is caused by a virus and can be transferred from one susceptible variety or tree to another by grafting. If diseased Bosc buds are placed in healthy Anjou trees, most fruits on those trees become pitted by the end of the second season. Such control of the disease as is possible depends on the use of budwood from healthy trees only and the removal of severely affected trees. The Bartlett variety is a symptomless carrier of the virus, and its use is possible where the disease prevails. Less severely affected trees of susceptible varieties may be top-worked to Bartlett if compatible. A record should be kept of such top-worked trees, since they form a virus reservoir that is always potentially dangerous.

In stony pit, masses, or lumps, of stone cells occur in the flesh of pears just under the skin at the bottoms of dimplelike depressions (pl. 12, *G*, *H*). When the pitting is severe and the pits are numerous, the fruit may be very much distorted. The lumps of stone cells are so hard that it is almost impossible to cut them. The pits are often bordered by darker green rings, and corky tissue may develop around the masses of stone cells.

Corky spot, so far as known, occurs only on the Anjou variety and has been reported only in California and the Pacific Northwest. It is characterized chiefly by a bumpy, uneven appearance of the pear surface as the fruit approaches maturity (pl. 12, *E*). Affected areas usually have a more yellow mature color than the rest of the surface. When diseased fruits are peeled or cut, large masses of brown or grayish necrotic tissue are seen to underlie the spots (pl. 12, *F*); unlike the masses of stone cells of stony pit, these masses offer little or no resistance to the knife, although the fruit containing them sometimes becomes gritty, because of the production of stone cells in the affected tissue.

The cause of corky spot is unknown. Heavy dormant pruning increases the percentage of fruits showing corky spots in the Wenatchee, Wash., district, whereas in the vicinity of Hood River, Oreg., the disease seems to be associated with black end, which occurs only when the trees are on Japanese pear rootstock. Corky spot is thought to be initiated during periods of high transpiration in trees whose root systems are inadequate to supply moisture during the critical period. Such inadequacy may be due to root injury on Japanese rootstock resulting from rapid fluctuations of soil moisture or other factors.

Pits resulting from boron deficiency are found in Bartlett, Bosc, and Anjou pears, but are not known to occur in other varieties. These are shallow, with rather steep sides, and usually have flat bottoms (pl. 12, *C*). The last-mentioned characteristic makes them distinguishable from stony pit and corky spot. The pits are easily cut and the spot of spongy tissue underneath them is usually less extensive than in corky spot (pl. 12, *D*).

Boric acid or borax applied at the rate of 30 to 50 pounds per acre has been found to correct the trouble. One application in early spring is usually sufficient for 3 years.

(See *73, 74, 96.*)

QUINCES

Black Rot

(See Apples, Black Rot, p. 14.)

Black Spot

(*Fabraea maculata* Atk.)

The black spot fungus causes leaf spotting on pear and quince, which is sometimes serious on nursery stock. If this disease is not controlled the causal fungus may spread to fruit and cause serious spotting (pl. 11, *B, C*). The disease is most common east of the Mississippi River and has not been reported on fruit grown in California and the Northwest. It does not develop or spread in storage or transit and is not commonly followed by rot of any kind.

Black spot manifests itself as black, circular, sunken areas ranging in diameter from about $\frac{1}{16}$ to $\frac{3}{8}$ inch and occurring on any part of a fruit. In the early stage the spots are usually surrounded by red rings, which may darken later. The surface may crack like that of spots affected with pear scab.

Commercial control of the disease can be obtained by spraying in accordance with recommendations of the local agricultural experiment station.

(See *59, 65.*)

Blue Mold Rot

(See Apples, Blue Mold Rot, p. 16.)

Brown Rot

(See Apples, Brown Rot, p. 20.)

Oriental Fruit Moth Injury

(*Grapholitha molesta* (Busck))

Quinces are often found at harvesttime to be completely honeycombed with tunnels caused by the oriental fruit moth (pl. 15, *C*). Although this insect has received attention chiefly as a peach pest, it has a particular preference for quince.

The New York State Agricultural Experiment Station has found that the oriental fruit moth can be controlled on quince by repeated applications of lead arsenate, of nicotine sulfate and summer oil, or of nicotine bentonite. The lead arsenate program results in residues that should be removed before the fruit is marketed. DDT, which has given good control of the oriental fruit moth on peach, should be effective against it on quince.

(See *32.*)

LITERATURE CITED

(1) ALLEN, F. W.
1932. MATURITY AND RATE OF RIPENING OF GRAVENSTEIN APPLES IN RELATION TO BITTER PIT DEVELOPMENT. Amer. Soc. Hort. Sci. Proc. (1931) 28: 639–645, illus.

(2) ALLEN, T. C., and RIKER, A. J.
1932. A ROT OF APPLE FRUIT CAUSED BY PHYTOMONAS MELOPHTHORA, N. SP., FOLLOWING INVASION BY THE APPLE MAGGOT. Phytopathology 22: 557–571, illus.

(3) ASKEW, H. O., and CHITTENDEN, E.
1936. THE USE OF BORAX IN THE CONTROL OF "INTERNAL CORK" OF APPLES. Jour. Pomol. and Hort. Sci. 14: 227–245, illus.

(4) BAILEY, J. S., and THIES, W. H.
1937. SOME OBSERVATIONS ON INTERNAL CORK DISEASE OF APPLES IN MASSACHUSETTS. Amer. Soc. Hort. Sci. Proc. (1936) 34: 187–191, illus.

(5) BAKER, K. F., and HEALD, F. D.
1932. THE IMPORTANCE OF LENTICEL INFECTION OF APPLES BY PENICILLIUM EXPANSUM. Wash. Agr. Expt. Sta. Bul. 264, 15 pp., illus.

(6) ——— and HEALD, F. D.
1932. SOME PROBLEMS CONCERNING BLUE MOLD IN RELATION TO CLEANING AND PACKING OF APPLES. Phytopathology 22: 879–898, illus.

(7) BALLARD, W. S., MAGNESS, J. R., and HAWKINS, L. A.
1922. INTERNAL BROWNING OF THE YELLOW NEWTOWN APPLE. U. S. Dept. Agr. Bul. 1104, 24 pp., illus.

(8) BATJER, L. P.
1946. MINOR ELEMENTS IN ORCHARD FERTILIZATION. Wash. State Hort. Assoc. Proc. 42: 179–180, 182–183.

(9) BRATLEY, C. O.
1937. INCIDENCE AND DEVELOPMENT OF APPLE SCAB ON FRUIT DURING THE LATE SUMMER AND WHILE IN STORAGE. U. S. Dept. Agr. Tech. Bul. 563, 46 pp., illus.

(10) BROOKS, C.
1908. THE FRUIT SPOT OF APPLES. N. H. Agr. Expt. Sta. Rpts. 19–20: 332–365, illus.

(11) ——— and COOLEY, J. S.
1917. TEMPERATURE RELATIONS OF APPLE-ROT FUNGI. Jour. Agr. Res. 8: 139–164, illus.

(12) ——— COOLEY, J. S., and FISHER, D. F.
1935. DISEASES OF APPLES IN STORAGE. U. S. Dept. Agr. Farmers' Bul. 1160, 20 pp., illus. (Revised.)

(13) ——— and FISHER, D. F.
1918. IRRIGATION EXPERIMENTS ON APPLE-SPOT DISEASES. Jour. Agr. Res. 12: 109–138, illus.

(14) ——— and FISHER, D. F.
1926. SOME HIGH-TEMPERATURE EFFECTS IN APPLES: CONTRASTS IN THE TWO SIDES OF AN APPLE. Jour. Agr. Res. 32: 1–16, illus.

(15) ——— and FISHER, D. F.
1926. WATER-CORE OF APPLES. Jour. Agr. Res. 32: 223–260, illus.

(16) ——— and HARLEY, C. P.
1934. SOFT SCALD AND SOGGY BREAK-DOWN OF APPLES. Jour. Agr. Res. 49: 55–69, illus.

(17) ——— MILLER, E. V., BRATLEY, C. O., and others.
1932. EFFECT OF SOLID AND GASEOUS CARBON DIOXIDE UPON TRANSIT DISEASES OF CERTAIN FRUITS AND VEGETABLES. U. S. Dept. Agr. Tech. Bul. 318, 60 pp., illus.

(18) BURRELL, A. B.
1937. BORON TREATMENT FOR A PHYSIOGENIC APPLE DISEASE. Amer. Soc. Hort. Sci. Proc. (1936) 34: 199–205.

(19) ———
1940. THE BORON-DEFICIENCY DISEASE OF APPLE. N. Y. Agr. Col. (Cornell) Ext. Bul. 428, 28 pp., illus.

(20) BUTLER, L. F.
1930. CORTICIUM CENTRIFUGUM, A HETEROTHALLIC PATHOGENE OF APPLES. Jour. Agr. Res. 41: 269–294, illus.

(21) BUTLER, O. R., and DUNN, S.
1941. BITTER-PIT DISEASE OF APPLES. N. H. Agr. Expt. Sta. Tech. Bul. 78, 10 pp.
(22) CARNE, W. M.
[1928.] BITTER PIT IN APPLES. SOME RECENT INVESTIGATIONS. West. Austral. Dept. Agr. Leaflet 219, 11 pp., illus.
(23) CARRICK, D. B.
1924. SOME EFFECTS OF FREEZING ON MATURE FRUITS OF THE APPLE. N. Y. (Cornell) Agr. Expt. Sta. Mem. 81, 54 pp., illus.
(24) CHAPMAN, P. J., and HESS, A. D.
1941. MORTALITY OF THE APPLE MAGGOT IN FRUIT HELD IN COLD STORAGE. U. S. Dept. Agr. Cir. 600, 10 pp., illus.
(25) CHILDS, L.
1927. TWO SPECIES OF THRIPS INJURIOUS TO APPLES IN THE PACIFIC NORTHWEST. Jour. Econ. Ent. 20: 805–808, illus.
(26) ———
1929. THE RELATION OF WOOLLY APPLE APHIS TO PERENNIAL CANKER INFECTION WITH OTHER NOTES ON THE DISEASE. Oreg. Agr. Expt. Sta. Bul. 243, 31 pp., illus.
(27) CHRISTOPHER, E. P.
1947. THE USE OF CO_2 TO PREVENT SCALD OF STORED APPLES. Refrig. Engin. 53: 311–314, 342, 344, 346, illus.
(28) CLINTON, G. P.
1920. DOWNY MILDEW ROT, PHYTOPHTHORA CACTORUM (COHN & LEB.) SCHROET. *In his* New or Unusual Plant Injuries and Diseases Found in Connecticut, 1916–1919. Conn. (New Haven) Agr. Expt. Sta. Bul. 222, pp. [395]–482, illus.
(29) COOLEY, J. S.
1932. BOTRYTIS STEM INFECTION IN PEARS. Phytopathology 22: 269–270.
(30) ——— and CRENSHAW, J. H.
1931. CONTROL OF BOTRYTIS ROT OF PEARS WITH CHEMICALLY TREATED WRAPPERS. U. S. Dept. Agr. Cir. 177, 10 pp., illus.
(31) CUMMINGS, M. B., and DUNNING, R. G.
1940. BITTER PIT OF APPLE. I. IN ORCHARD AND IN STORAGE. Vt. Agr. Expt. Sta. Bul. 467, 30 pp., illus.
(32) DANIEL, D. M., and COX, J. A.
1936. ORIENTAL FRUIT MOTH CONTROL IN QUINCE PLANTINGS. N. Y. (Geneva) Agr. Expt. Sta. Bul. 669, 16 pp., illus.
(33) DAVIS, L. D., and TUFTS, W. P.
1932. BLACK-END AND ITS OCCURRENCE IN SELECTED PEAR ORCHARDS. Amer. Soc. Hort. Sci. Proc. (1931) 28: 634–638, illus.
(34) DEGMAN, E. S., BATJER, L. P., REGEIMBAL, L. O., and MAGNESS, J. R.
1938. FURTHER INVESTIGATIONS ON THE USE OF BORON FOR CONTROL OF INTERNAL CORK OF APPLES. Amer. Soc. Hort. Sci. Proc. (1937) 35: 165–168.
(35) DIEHL, H. C., and WRIGHT, R. C.
1924. FREEZING INJURY OF APPLES. Jour. Agr. Res. 29: 99–127, illus.
(36) DUTTON, W. C.
1932. SPRAY INJURY STUDIES. I. INJURIES FROM SUMMER APPLICATION ON THE APPLE. Mich. Agr. Expt. Sta. Spec. Bul. 218, 68 pp., illus.
(37) ENGLISH, H., RYALL, A. L., and SMITH, E.
1946. BLUE MOLD DECAY OF DELICIOUS APPLES IN RELATION TO HANDLING PRACTICES. U. S. Dept. Agr. Cir. 751, 20 pp., illus.
(38) ——— WRIGHT, T. R., and SMITH, E.
1948. CHEMICALS CUT STORAGE LOSSES. Better Fruit 43 (2): [9–11], 22.
(39) FISHER, D. F.
1928. APPLES AND PEARS ARE OFTEN INJURED WHEN BOXED IN DOUGLAS FIR. U. S. Dept. Agr. Yearbook 1927: 106–107, illus.
(40) ———
1935. CORK INJURIES AND INTERNAL BREAKDOWN OF APPLES. Md. State Hort. Soc. Proc. 37: 18–22.
(41) ———
1937. YORK SKIN CRACK, HYDROCHLORIC INJURY, AND HEAT CRACKING. Amer. Fruit Grower 57: [11], 16, illus.

(42) FISHER, D. F.
1938. CONTROL OF APPLE POWDERY MILDEW. U. S. Dept. Agr. Farmers' Bul. 1120, 10 pp., illus. (Revised.)
(43) ———
1942. HANDLING APPLES FROM TREE TO TABLE. U. S. Dept. Agr. Cir. 659, 39 pp., illus.
(44) ——— and COOLEY, J. S.
1947. APPLE SCALD AND ITS CONTROL. U. S. Dept. Agr. Farmers' Bul. 1380, 9 pp., illus. (Revised.)
(45) ——— HARLEY, C. P., and BROOKS, C.
1931. THE INFLUENCE OF TEMPERATURE ON THE DEVELOPMENT OF WATERCORE. Amer. Soc. Hort. Sci. Proc. (1930) 27: 276–280.
(46) ——— and REEVES, E. L.
1931. ARSENICAL AND OTHER FRUIT INJURIES OF APPLES RESULTING FROM WASHING OPERATIONS. U. S. Dept. Agr. Tech. Bul. 245, 12 pp., illus.
(47) FULTON, B. B.
1918. INSECT INJURIES OF APPLE FRUIT. N. Y. (Geneva) Agr. Expt. Sta. Cir. 57, 15 pp., illus.
(48) ———
1920. INSECT INJURIES IN RELATION TO APPLE GRADING. N. Y. (Geneva) Agr. Expt. Sta. Bul. 475, 42 pp., illus.
(49) HALLER, M. H., and BATJER, L. P.
1946. STORAGE QUALITY OF APPLES IN RELATION TO SOIL APPLICATIONS OF BORON. Jour. Agr. Res. 73: 243–253, illus.
(50) ——— and LUTZ, J. M.
1937. SOFT SCALD OF JONATHAN APPLES IN RELATION TO RESPIRATION. Amer. Soc. Hort. Sci. Proc. (1936) 34: 173–176, illus.
(51) ——— and SMITH, E.
1950. EVALUATION OF INDEXES OF MATURITY FOR APPLES. U. S. Dept. Agr. Tech. Bul. 1003, 53 pp., illus.
(52) HARLEY, C. P.
1929. RELATION OF PICKING TIME TO ACETALDEHYDE CONTENT AND CORE BREAKDOWN OF BARTLETT PEARS. Jour. Agr. Res. 39: 483–493, illus.
(53) ——— and FISHER, D. F.
1927. THE OCCURRENCE OF ACETALDEHYDE IN BARTLETT PEARS AND ITS RELATION TO PEAR SCALD AND BREAKDOWN. Jour. Agr. Res. 35: 983–993.
(54) HARTMAN, H.
1931. A PRELIMINARY REPORT ON ANJOU SCALD AND ITS CONTROL. Oreg. Agr. Expt. Sta. Bul. 280, 8 pp., illus.
(55) ———
1931. A PECULIAR FREEZING TROUBLE OF PEARS IN COLD STORAGE. Oreg. Agr. Expt. Sta. Bul. 282, 8 pp., illus.
(56) ———
1932. THE HANDLING OF PEARS ON EASTERN MARKETS. Ice and Refrig. 82: 373–374.
(57) ——— CHILDS, L., and ROBINSON, R. H.
1929. THE OCCURRENCE AND PREVENTION OF CALYX INJURY IN APPLES FROM THE HOOD RIVER VALLEY. Oreg. Agr. Expt. Sta. Bul. 242, 23 pp., illus.
(58) HEALD, F. D.
[1928.] BLUE MOLD IN RELATION TO FRUIT CLEANING METHODS. Wash. State Hort. Assoc. Proc. (1927) 23: 143–148.
(59) ———
1933. MANUAL OF PLANT DISEASES. Ed. 2, 953 pp., illus. New York and London.
(60) ——— and RUEHLE, G. D.
1931. THE ROTS OF WASHINGTON APPLES IN COLD STORAGE. Wash. Agr. Expt. Sta. Bul. 253, 48 pp., illus.
(61) ——— and SPRAGUE, R.
1926. A SPOT-ROT OF APPLES IN STORAGE CAUSED BY BOTRYTIS. Phytopathology 16: 485–488, illus.
(62) HEINICKE, A. J.
1950. WHAT CAUSES STIPPEN AND WHAT CAN BE DONE ABOUT IT. N. Y. Hort. Soc. Proc. 95: 178–183.

(63) Heppner, M. J.
[1928.] pear black-end and its relation to different rootstocks. Amer. Soc. Hort. Sci. Proc. (1927) 24: 139–142.
(64) Hesler, L. R.
1916. black rot, leaf spot, and canker of pomaceous fruits. N. Y. (Cornell) Agr. Expt. Sta. Bul. 379, pp. [49]–148, illus.
(65) ——— and Whetzel, H. H.
1917. manual of fruit diseases. 462 pp., illus. New York.
(66) Huber, G. A.
1930. the aspergilli and their relation to decay in apples. Jour. Agr. Res. 41: 801–817, illus.
(67) Hukill, W. V., and Smith, E.
1946. cold storage for apples and pears. U. S. Dept. Agr. Cir. 740, 61 pp., illus.
(68) Hunt, T. F.
1923. effect of ammonia fumes upon pears in cold storage. Calif. Agr. Expt. Sta. Rpt. 1922–23: 201–203, illus.
(69) Keitt, G. W., and Jones, L. K.
1926. studies of the epidemiology and control of apple scab. Wis. Agr. Expt. Sta. Res. Bul. 73, 104 pp., illus.
(70) Kidd, F., and West, C.
1925. functional diseases of apples in cold storage. [Gt. Brit.] Dept. Sci. and Indus. Res., Food Invest. Bd. Spec. Rpt. 23, 15 pp., illus.
(71) ——— and West, C.
1930. the gas storage of fruit. II. optimum temperatures and atmospheres. Jour. Pomol. and Hort. Sci. 8: 67–77, illus.
(72) Kienholz, J. R.
1939. comparative study of the apple anthracnose and perennial canker fungi. Jour. Agr. Res. 59: 635–665, illus.
(73) ———
1939. stony pit, a transmissible disease of pears. Phytopathology 29: 260–267, illus.
(74) ———
1944. observations on certain pits and other blemishes of pear fruits. Wash. State Hort. Assoc. Proc. (1943) 39: 51–57.
(75) ———
1948. chemicals aid hood river pears. Better Fruit 43 (2): 12, 21.
(76) ——— Robinson, R. H., and Degman, E. S.
[1949.] reduction of pear rots in oregon by the use of a chemical wash. Oreg. Agr. Expt. Sta. Cir. Inf. 460, 7 pp. [Processed.]
(77) Kraus, E. J.
1916. variation of internal structure of apple varieties. Oreg. Agr. Expt. Sta. Bul. 135, 42 pp., illus.
(78) Latimer, L. P.
1941. relation of weather to prevalence of internal cork in apples. Amer. Soc. Hort. Sci. Proc. 38: 63–69, illus.
(79) McAlpine, D.
1915. bitter pit investigation: the experimental results in their relation to bitter pit and a general summary of the investigation. Fourth Rpt., 1914–15, 178 pp., illus. Melbourne.
(80) McColloch, L. P.
1944. a study of the apple rot fungus phialophora malorum. Mycologia 36: 576–590, illus.
(81) MacDaniels, L. H., and Heinicke, A. J.
1930. to what extent is "spray burn" of apple fruit caused by the freezing of the flowers? Phytopathology 20: 903–906, illus.
(82) McLarty, H. R.
1936. tree injections with boron and other materials as a control for drought spot and corky core of apple. Sci. Agr. 16: [625]–633, illus.
(83) Magness, J. R.
1920. investigations in the ripening and storage of bartlett pears. Jour. Agr. Res. 19: 473–500, illus.

(84) MAGNESS, J. R., DEGMAN, E. S., BATJER, L. P., and REGEIMBAL, L. O.
1937. EFFECT OF NUTRITIONAL TREATMENTS ON INTERNAL CORK OF APPLES. Amer. Soc. Hort. Sci. Proc. (1936) 34: 206–209, illus.

(85) ——— and DIEHL, H. C.
1924. PHYSIOLOGICAL STUDIES ON APPLES IN STORAGE. Jour. Agr. Res. 27: 1–38, illus.

(86) ——— DIEHL, H. C., and ALLEN, F. W.
1929. INVESTIGATIONS ON THE HANDLING OF BARTLETT PEARS FROM PACIFIC COAST DISTRICTS. U. S. Dept. Agr. Tech. Bul. 140, 28 pp., illus.

(87) ——— DIEHL, H. C., HALLER, M. H., and others.
1926. THE RIPENING, STORAGE, AND HANDLING OF APPLES. U. S. Dept. Agr. Dept. Bul. 1406, 64 pp., illus.

(88) MILLER, P. R.
1932. PATHOGENICITY OF THREE RED-CEDAR RUSTS THAT OCCUR ON APPLE. Phytopathology 22: 723–740, illus.

(89) MIX, A. J.
1916. CORK, DROUTH SPOT AND RELATED DISEASES OF THE APPLE. N. Y. (Geneva) Agr. Expt. Sta. Bul. 426, pp. 473–522, illus.

(90) MOGENDORFF, N.
1925. SOME CHEMICAL FACTORS INVOLVED IN ARSENICAL INJURY OF FRUIT TREES. N. J. Agr. Expt. Sta. Bul. 419, 47 pp., illus.

(91) MUESEBECK, C. F.
1950. COMMON NAMES OF INSECTS APPROVED BY THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS. Jour. Econ. Ent. 43: 117–138.

(92) NELLER, J. R.
1931. RELATION OF CATALASE ACTIVITY TO PHYSIOLOGICAL BREAKDOWN IN JONATHAN APPLES. Plant Physiol. 6: 347–354, illus.

(93) NEWCOMER, E. J.
1941. ORCHARD INSECTS OF THE PACIFIC NORTHWEST AND THEIR CONTROL. U. S. Dept. Agr. Cir. 270, 80 pp., illus. (Revised.)

(94) NEWTON, G. A.
1928. SOME FUNGI OF THE STEMPHYLIUM TYPE AND THEIR RELATION TO APPLE ROTS. Phytopathology 18: 565–578, illus.

(95) OVERHOLSER, E. L.
[1928.] A STUDY OF THE HARVESTING AND THE STORAGE OF GRAVENSTEIN APPLES. Amer. Soc. Hort. Sci. Proc. (1927) 24: 252–255.

(96) ——— OVERLEY, F. L., and ALLMENDINGER, D. F.
1944. PEAR GROWING AND HANDLING IN WASHINGTON. Wash. Agr. Expt. Sta. Pop. Bul. 174, 84 pp., illus.

(97) ——— WINKLER, A. J., and JACOB, H. E.
1923. FACTORS INFLUENCING THE DEVELOPMENT OF INTERNAL BROWNING OF THE YELLOW NEWTOWN APPLE. Calif. Agr. Expt. Sta. Bul. 370, 40 pp., illus.

(98) PALMER, R. C.
1930. RECENT PROGRESS IN THE CONTROL OF JONATHAN BREAKDOWN. Wash. State Hort. Assoc. Proc. (1929) 26: 99–102.

(99) ———
1943. THE INFLUENCE OF AMOUNT OF CROP AND HARVESTING MATURITY ON BITTER PIT IN OKANAGAN-GROWN NEWTOWN APPLES. Amer. Soc. Hort. Sci. Proc. 43: 63–68, illus.

(100) PARSONS, M. S.
1931. SOME ECONOMIC PHASES OF THE MARKETING OF MAINE APPLES. Maine Agr. Expt. Sta. Bul. 359, pp. [105]–164, illus.

(101) PEAIRS, L. M.
1941. INSECT PESTS OF FARM, GARDEN, AND ORCHARD. Ed. 4, 549 pp., illus. New York and London.

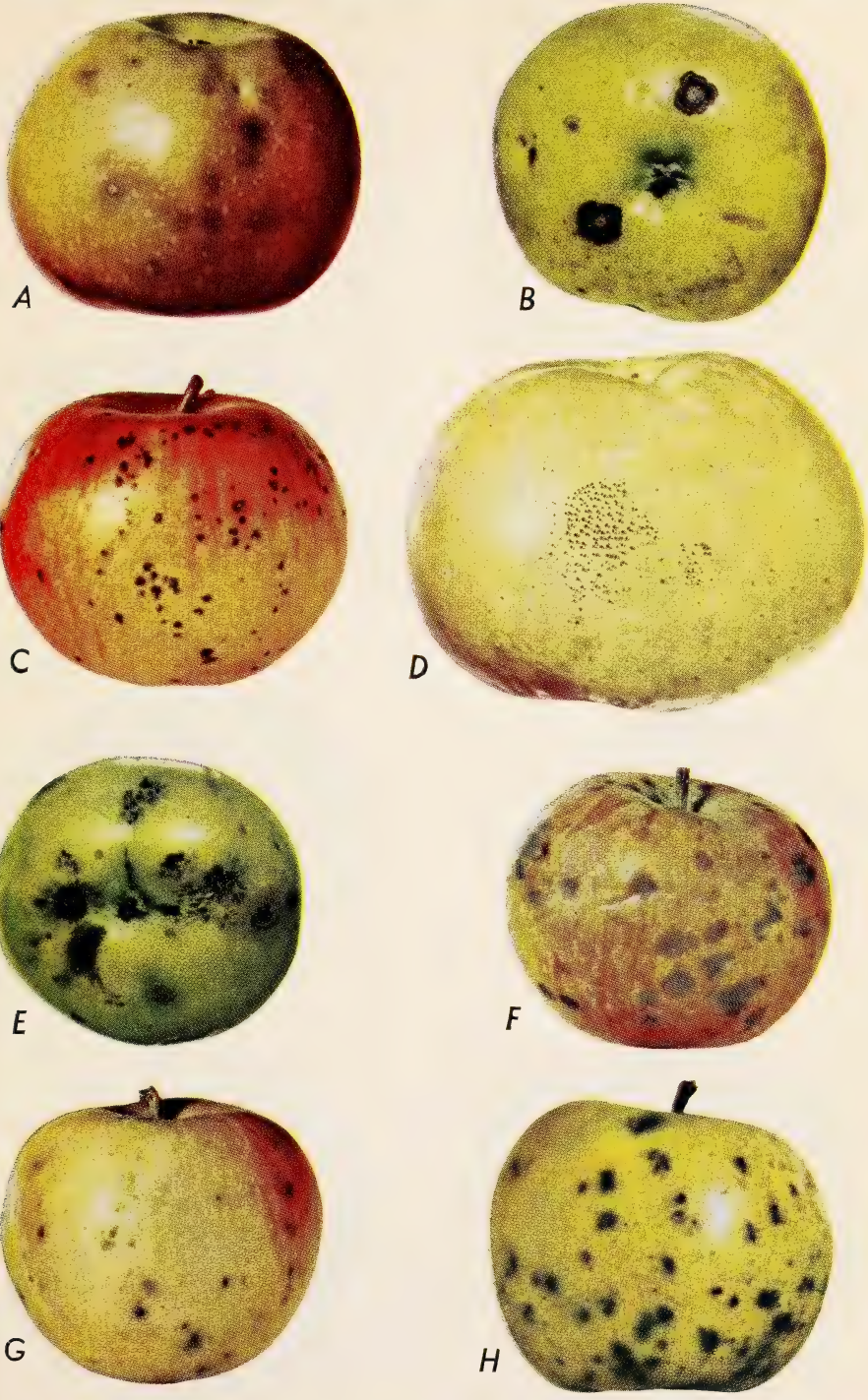
(102) PENTZER, W. T.
[1926.] COLOR PIGMENT IN RELATION TO THE DEVELOPMENT OF JONATHAN-SPOT. Amer. Soc. Hort. Sci. Proc. (1925) 22: 66–69.

(103) ——— MAGNESS, J. R., DIEHL, H. C., and HALLER, M. H.
1932. INVESTIGATIONS ON HARVESTING AND HANDLING FALL AND WINTER PEARS. U. S. Dept. Agr. Tech. Bul. 290, 30 pp., illus.

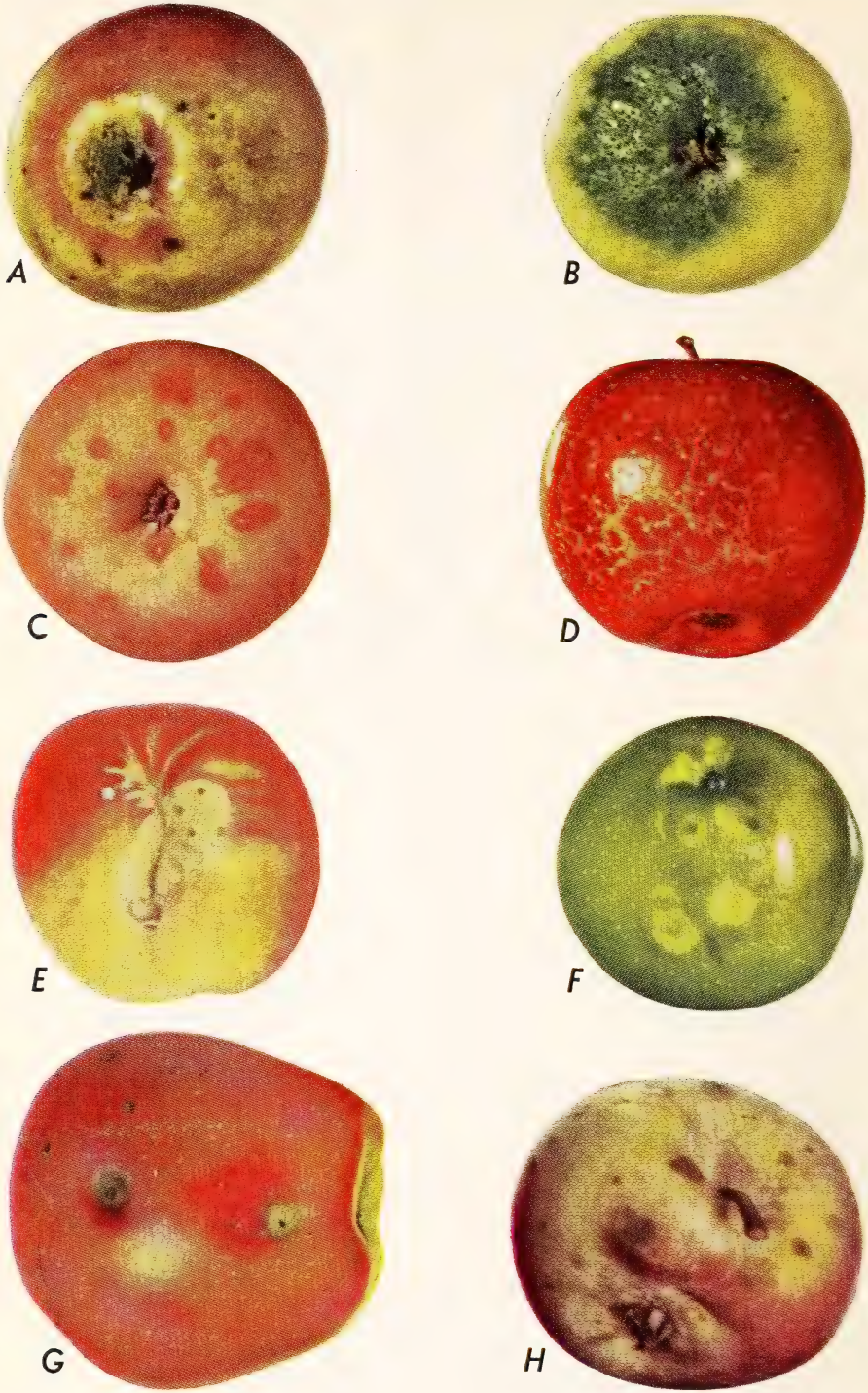
(104) PLAGGE, H. H.
1929. EFFECT OF STORAGE TEMPERATURE ON SOGGY BREAKDOWN OF GOLDEN DELICIOUS APPLES. Amer. Soc. Hort. Sci. Proc. (1928) 25: 298–300.
(105) ——— and MANEY, T. J.
1924. APPLE STORAGE INVESTIGATIONS. FOURTH PROGRESS REPORT. I. JONATHAN-SPOT AND SOFT-SCALD. II. APPLE-SCALD AND INTERNAL BREAKDOWN. Iowa Agr. Expt. Sta. Bul. 222, 64 pp., illus.
(106) ——— and MANEY, T. J.
1925. COLD STORAGE INVESTIGATIONS WITH WEALTHY APPLES. FIFTH PROGRESS REPORT. Iowa Agr. Expt. Sta. Bul. 230, pp. [59]–72, illus.
(107) ——— and MANEY, T. J.
1928. SOGGY BREAKDOWN OF APPLES AND ITS CONTROL BY STORAGE TEMPERATURE. Iowa Agr. Expt. Sta. Res. Bul. 115, pp. [61]–118, illus.
(108) ——— and MANEY, T. J.
1937. FACTORS INFLUENCING THE DEVELOPMENT OF SOGGY BREAK-DOWN IN APPLES. Jour. Agr. Res. 55: 739–763, illus.
(109) ——— MANEY, T. J., and GERHARDT, F.
1926. CERTAIN PHYSICAL AND CHEMICAL CHANGES OF GRIMES APPLES DURING RIPENING AND STORAGE PERIOD. Iowa Agr. Expt. Sta. Res. Bul. 91, pp. [42]–72, illus.
(110) RAMSEY, G. B., and BUTLER, L. F.
1928. INJURY TO ONIONS AND FRUITS CAUSED BY EXPOSURE TO AMMONIA. Jour. Agr. Res. 37: 339–348, illus.
(111) REES, H. L.
1914. BITTER ROT OF APPLES IN THE PACIFIC NORTHWEST. Phytopathology 4: 217–219.
(112) ROBERTS, J. W.
1917. APPLE BLOTCH AND ITS CONTROL. U. S. Dept. Agr. Bul. 534, 11 pp., illus.
(113) ——— and PIERCE, L.
1935. APPLE BITTER ROT AND ITS CONTROL. U. S. Dept. Agr. Farmers' Bul. 938, 10 pp., illus. (Revised.)
(114) ROSE, D. H.
1924. DISEASES OF APPLES ON THE MARKET. U. S. Dept. Agr. Dept. Bul. 1253, 24 pp., illus.
(115) ——— and LINDEGREN, C. C.
1925. PHYTOPHTHORA ROT OF PEARS AND APPLES. Jour. Agr. Res. 30: 463–468, illus.
(116) ——— and LUTZ, J. M.
1933. BRUISING AND FREEZING OF APPLES IN STORAGE AND TRANSIT. U. S. Dept. Agr. Tech. Bul. 370, 15 pp., illus.
(117) ——— and LUTZ, J. M.
1933. INJURY TO PEARS CAUSED BY PAPER LINERS IMPREGNATED WITH SODIUM SILICATE. Jour. Agr. Res. 47: 153–162, illus.
(118) ——— WRIGHT, R. C., and BRATLEY, C. O.
1944. FREEZING INJURY OF FRUITS AND VEGETABLES. U. S. Dept. Agr. Cir. 713, 31 pp., illus.
(119) ——— WRIGHT, R. C., and WHITEMAN, T. M.
1949. THE COMMERCIAL STORAGE OF FRUITS, VEGETABLES, AND FLORISTS' STOCKS. U. S. Dept. Agr. Cir. 278, 60 pp. (Revised.)
(120) RUEHLE, G. D.
1931. NEW APPLE-ROT FUNGI FROM WASHINGTON. Phytopathology 21: 1141–1152, illus.
(121) SCHRADER, A. L., and HAUT, I. C.
1938. SKIN-CRACKING OF YORK APPLES AS RELATED TO SPRAY INJURY. Amer. Soc. Hort. Sci. Proc. (1937) 35: 180–183, illus.
(122) SCHRENK, H. VON, and SPAULDING, P.
1903. THE BITTER ROT OF APPLES. U. S. Bur. Plant Indus. Bul. 44, 54 pp., illus.
(123) SMITH, W. W.
1942. DEVELOPMENT OF THE STORAGE DISORDER BROWN CORE IN McINTOSH APPLES. Amer. Soc. Hort. Sci. Proc. 41: 99–103, illus.

(124) SMOCK, R. M.
1941. STUDIES ON BITTER PIT OF THE APPLE. N. Y. (Cornell) Agr. Expt. Sta. Mem. 234, 45 pp., illus.
(125) ———
1946. SOME FACTORS AFFECTING THE BROWN CORE DISEASE OF McINTOSH APPLES. Amer. Soc. Hort. Sci. Proc. 47: 67–74, illus.
(126) STAKMAN, E. C., and ROSE, R. C.
1914. A FRUIT SPOT OF THE WEALTHY APPLE. Phytopathology 4: 333–336, illus.
(127) STEVENS, F. L., and HALL, J. G.
1907. SOME APPLE DISEASES: THE VOLUTELLA ROT. N. C. Agr. Expt. Sta. Bul. 196, pp. [41]–48, illus.
(128) STILLINGER, C. R.
1920. APPLE BLACK ROT (SPHAEROPSIS MALORUM BERK.) IN OREGON. Phytopathology 10: [453]–458.
(129) THOMAS, H. E., and MILLS, W. D.
1929. THREE RUST DISEASES OF THE APPLE. N. Y. (Cornell) Agr. Expt. Sta. Mem. 123, 21 pp., illus.
(130) VERNER, L.
1935. A PHYSIOLOGICAL STUDY OF CRACKING IN APPLES. Jour. Agr. Res. 51: 191–222, illus.
(131) WALLACE, E.
1913. SCAB DISEASE OF APPLES. N. Y. (Cornell) Agr. Expt. Sta. Bul. 335, pp. 542–624, illus.
(132) WALTON, R. C., and ORTON, C. R.
1926. THE PERFECT STAGE OF CYLINDROSPORIUM POMI. Science 63: 236.
(133) WELLMAN, R. F., and HEALD, F. D.
1938. STEAM STERILIZATION OF APPLE BOXES FOR BLUE MOLD. Wash. Agr. Expt. Sta. Bul. 357, 16 pp.
(134) WHETZEL, H. H., and ROSENBAUM, J.
1916. THE PHYTOPHTHORA ROT OF APPLES. Phytopathology 6: [89]–90.
(135) WHITEHOUSE, W. E.
1919. COLD STORAGE FOR IOWA APPLES. THIRD PROGRESS REPORT. Iowa Agr. Expt. Sta. Bul. 192, pp. [177]–216, illus.
(136) WIANT, J. S., and BRATLEY, C. O.
1948. SPOILAGE OF FRESH FRUITS AND VEGETABLES IN RAIL SHIPMENTS UNLOADED AT NEW YORK CITY, 1935–42. U. S. Dept. Agr. Cir. 773, 62 pp.
(137) WILCOX, J. C.
1938. EFFECTS OF SOME FIELD PLOT TREATMENTS ON DROUGHT SPOT AND CORKY CORE OF THE APPLE. Sci. Agr. 18: 300–314, illus.
(138) WILSON, E. E.
1928. STUDIES OF THE ASCIGEROUS STAGE OF VENTURIA INAEQUALIS (CKE.) WINT. IN RELATION TO CERTAIN FACTORS OF THE ENVIRONMENT. Phytopathology 18: 375–418, illus.
(139) WINGARD, S. A.
1926. BLACK END OF APPLE. Phytopathology 16: 1011–1012, illus.
(140) WINKLER, A. J.
1923. A STUDY OF THE INTERNAL BROWNING OF THE YELLOW NEWTOWN APPLE. Jour. Agr. Res. 24: 165–184, illus.
(141) WRIGHT, R. C.
1937. THE FREEZING TEMPERATURES OF SOME FRUITS, VEGETABLES, AND FLORISTS' STOCKS. U. S. Dept. Agr. Cir. 447, 11 pp., illus.
(142) YOUNG, L. C., and BAILEY, C. F.
1936. PROGRESS REPORT ON THE INVESTIGATION OF CORKY CORE OF APPLES. Sci. Agr. 17: 115–127, illus.
(143) ZELLER, S. M.
1924. SPHAEROPSIS MALORUM AND MYXOSPORIUM CORTICOLA ON APPLE AND PEAR IN OREGON. Phytopathology 14: [329]–333.
(144) ———
1926. CANKERS OF APPLE AND PEAR IN OREGON AND THEIR CONTROL. Oreg. Agr. Expt. Sta. Cir. 73, 29 pp., illus.
(145) ——— and CHILDS, L.
1925. PERENNIAL CANKER OF APPLE TREES. Oreg. Agr. Expt. Sta. Bul. 217, 17 pp., illus.

☆ U. S. GOVERNMENT PRINTING OFFICE: 1951—892934

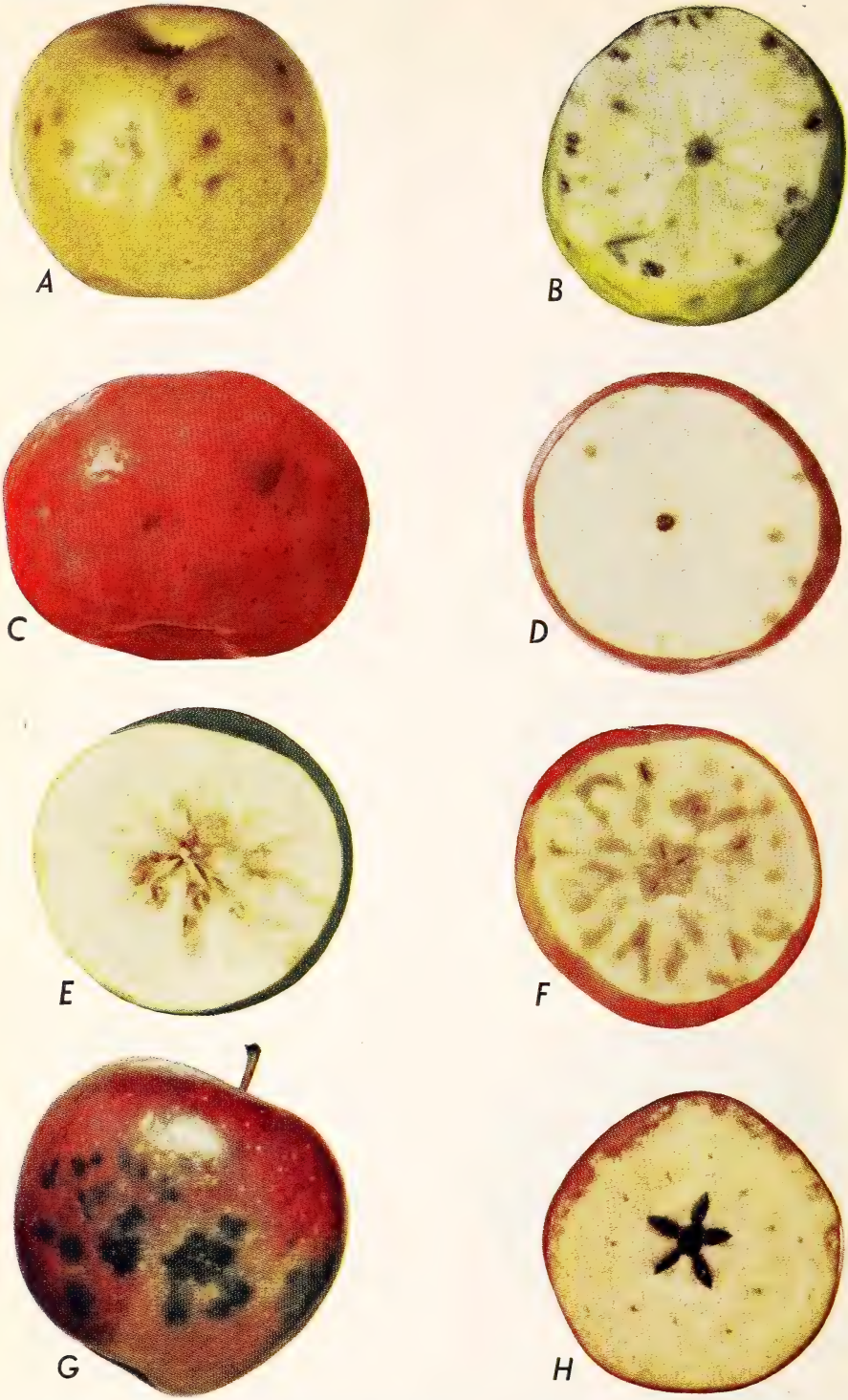


Apple diseases: *A*, Inactive scab at harvest; *B*, active scab at harvest; *C*, storage scab; *D*, flyspeck; *E*, blotch; *F*, sooty blotch; *G*, *H*, fruit spot (Brooks' spot).

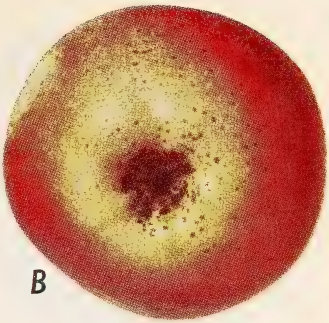


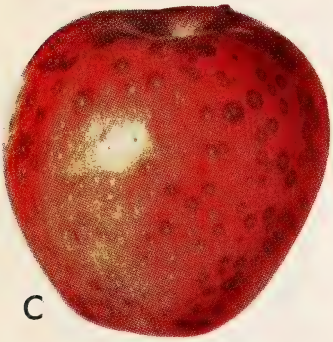
Apple diseases and insect injuries: *A*, Apple-cedar rust; *B*, quince rust; *C*, San Jose scale spotting; *D*, powdery mildew; *E*, leaf roller injury; *F*, pansy spot; *G*, codling moth sting injury; *H*, aphid injury.

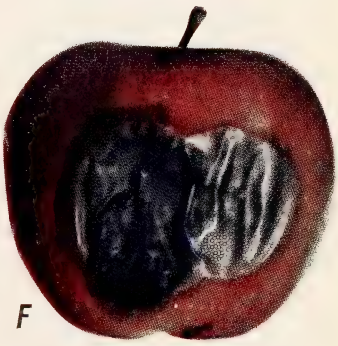
Apple injuries: *A*, Spray injury of the type caused by bordeaux mixture; *B*, sulfur injury; *C*, frost injury; *D*, hail injury; *E*, sunburn; *F*, sunscald; *G*, *H*, heat injury.

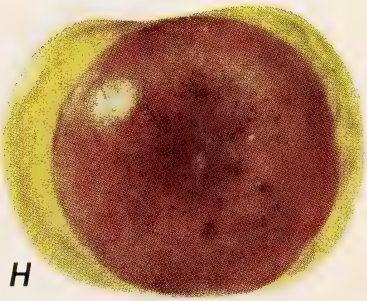


Apple diseases and injuries: *A*, *B*, Bitter pit; *C*, *D*, York spot, a form of bitter pit; *E*, internal cork in Grimes Golden; *F*, late-season internal cork in Cortland; *G*, *H*, stigmonose.

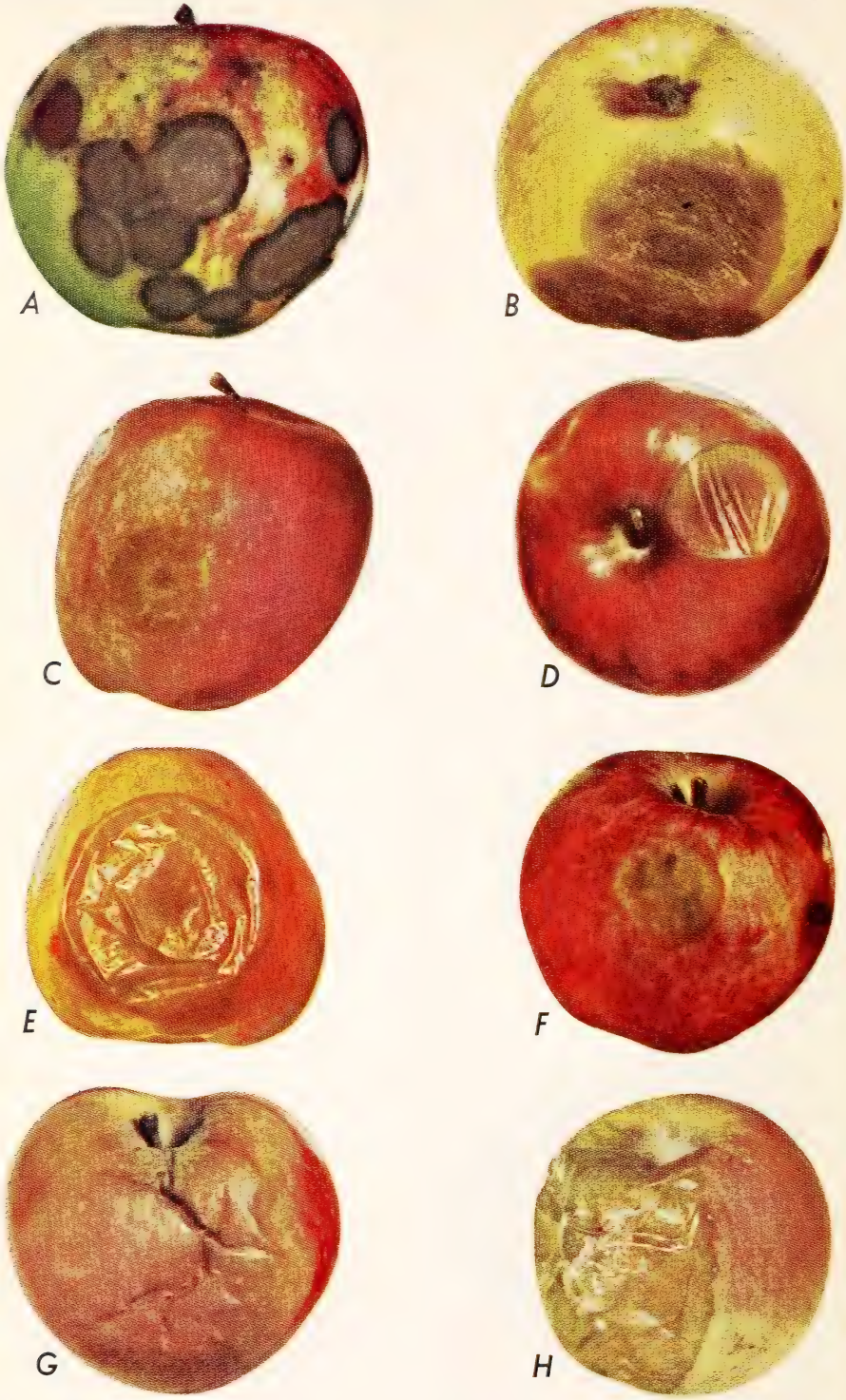




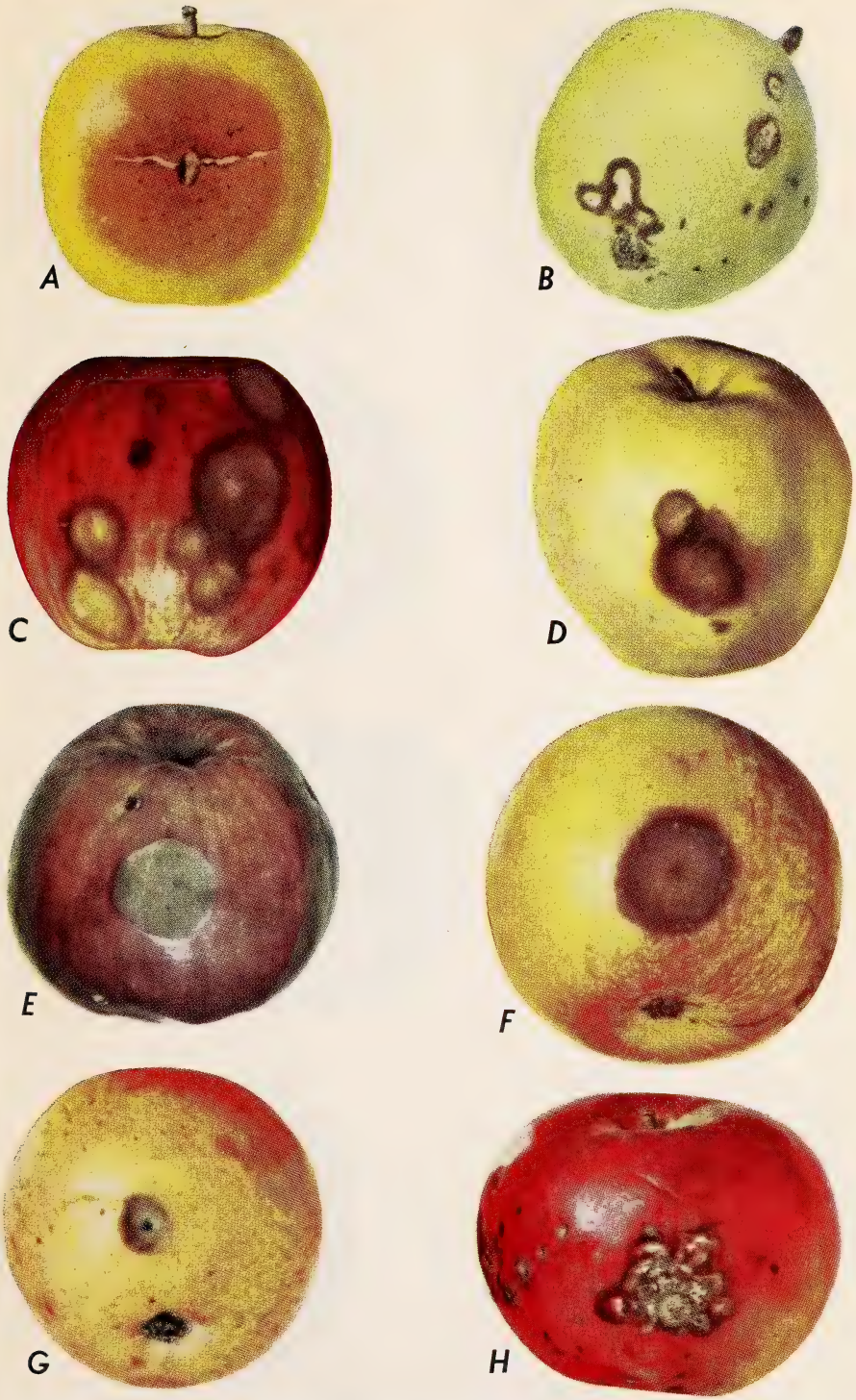




Apple chemical injuries and diseases: *A*, Acid injury; *B*, alkali injury; *C*, ammonia injury; *D*, sodium chloro-2-phenylphenate injury; *E*, alternaria rot (early stage); *F*, alternaria rot (advanced stage); *G*, black rot; *H*, brown rot.

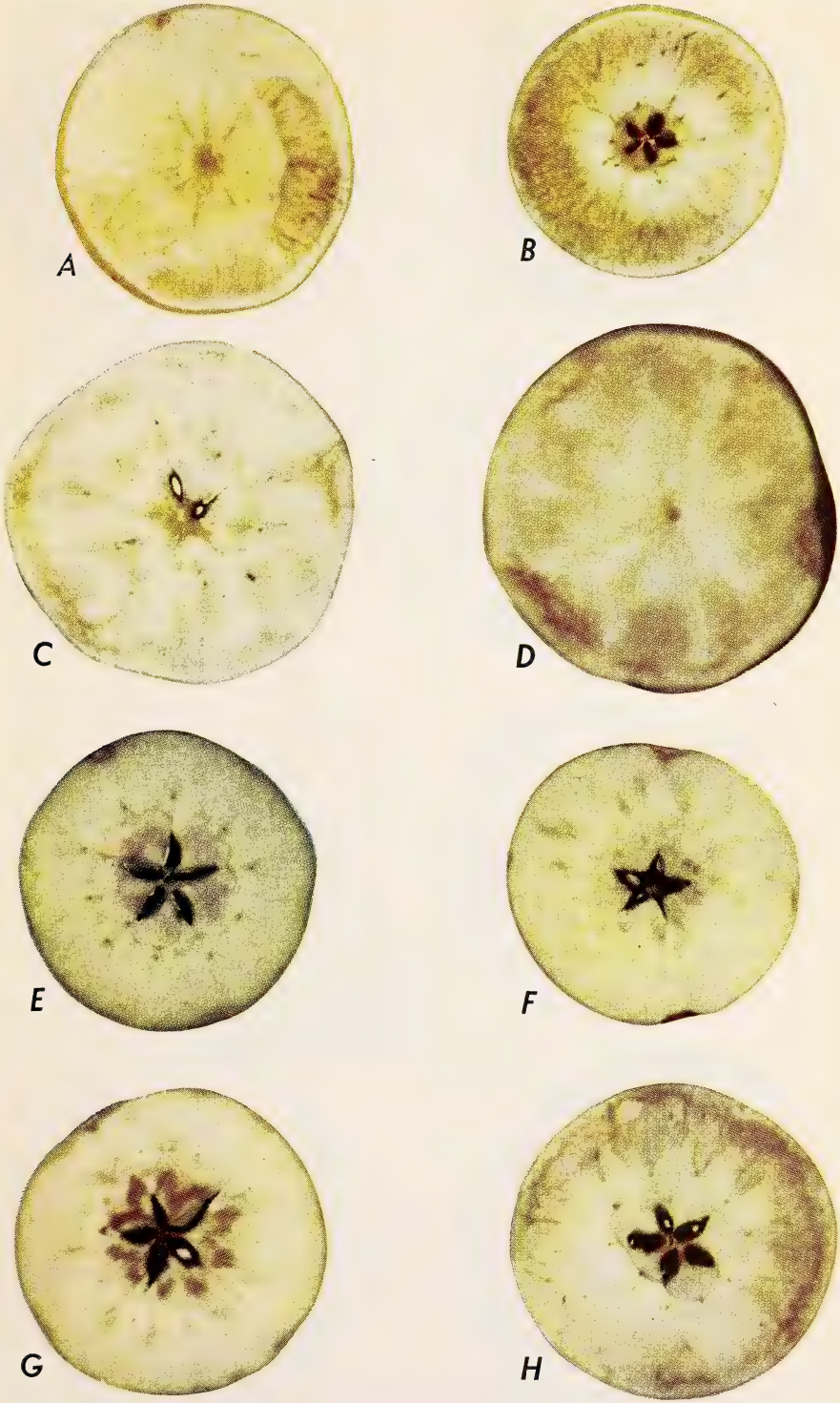


Apple diseases: *A*, *B*, Bitter rot; *C–E*, blue mold rot (early, medium, and advanced stages); *F–H*, gray mold rot (early and advanced stages).

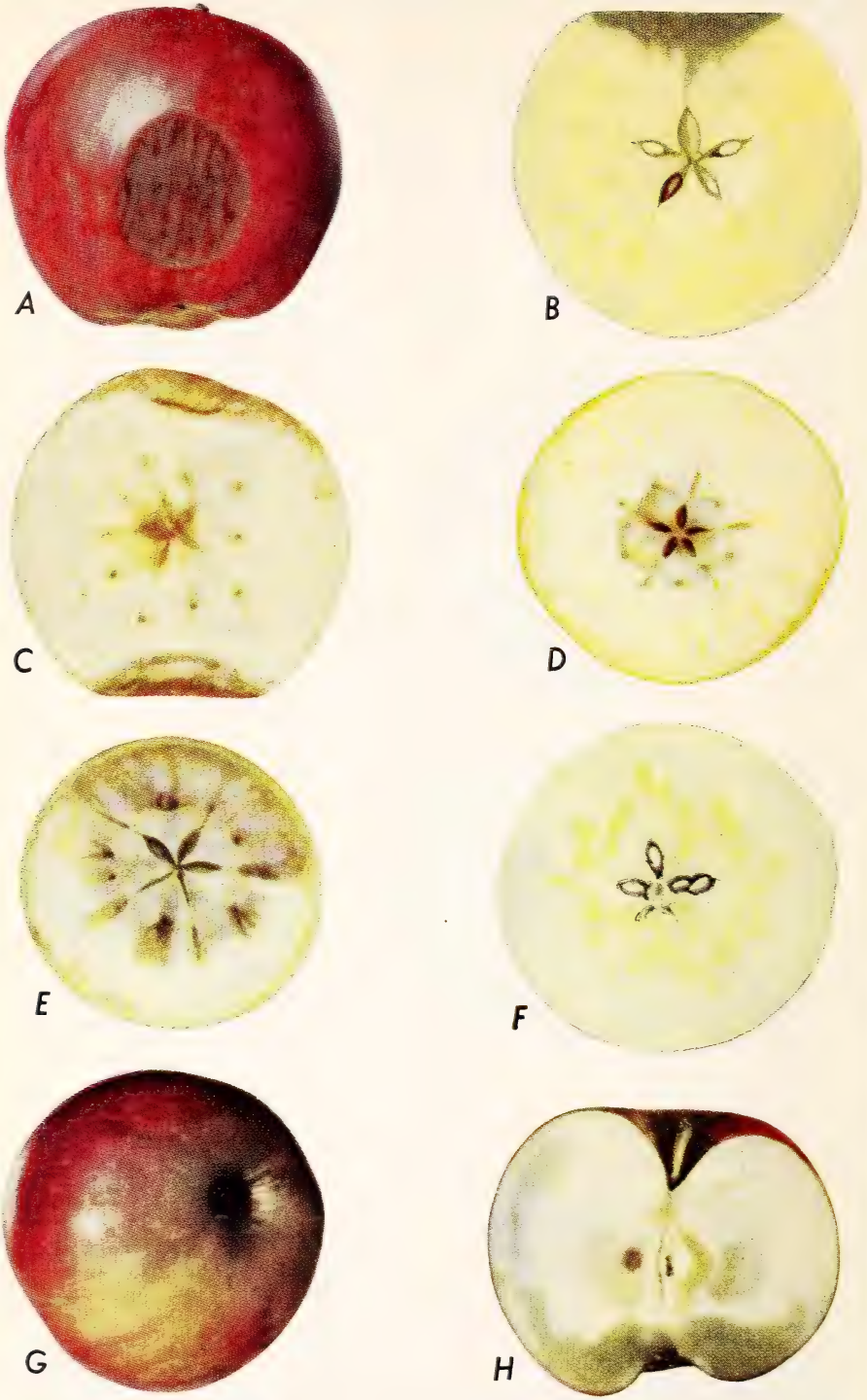


Apple diseases: *A*, Phytophthora rot; *B*, pink mold rot; *C*, *D*, bull's-eye rot; *E*, *F*, side rot; *G*, *H*, fisheye rot following scab.

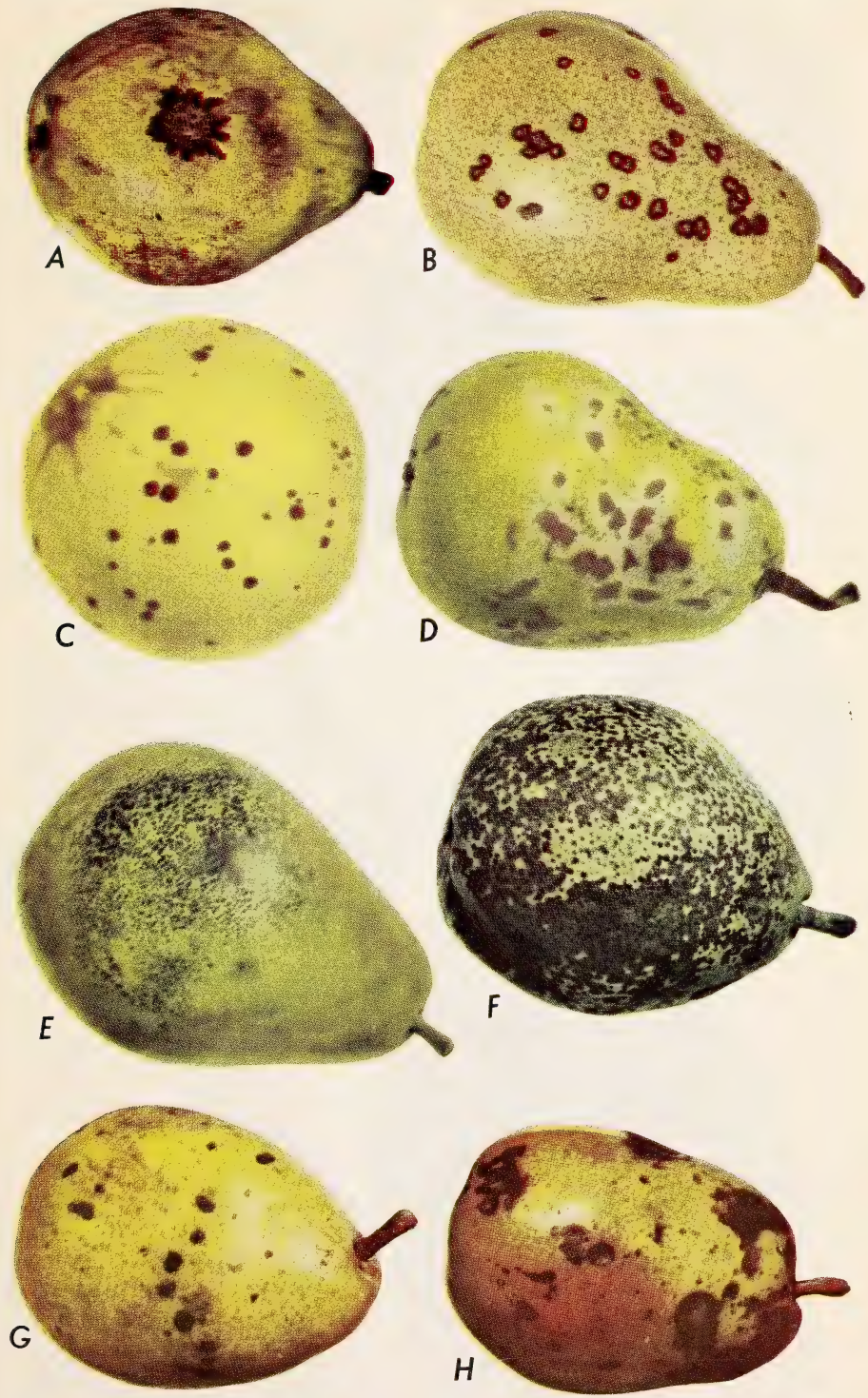
Apple diseases: *A–C*, Jonathan spot on Jonathan (*A*, *B*) and Rome Beauty (*C*); *D*, slight scald on Arkansas (Mammoth Black Twig); *E*, moderate scald on Grimes Golden; *F*, severe scald on Arkansas; *G*, *H*, soft scald on Jonathan.



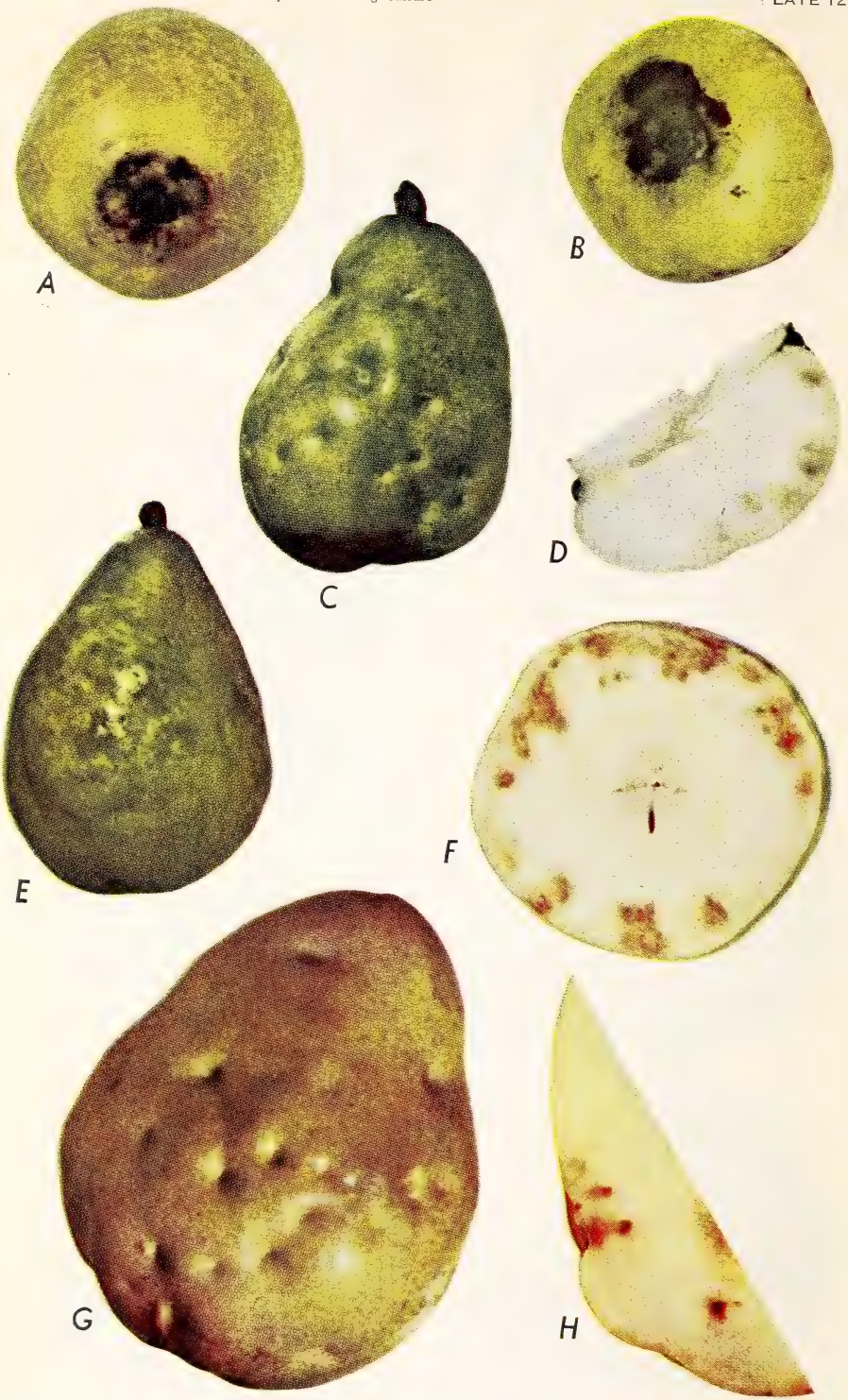
Apple diseases: *A*, *B*, Soggy break-down; *C*, *D*, internal browning in Yellow Newtown; *E*, brown core in Rhode Island Greening; *F*, *G*, brown core in McIntosh; *H*, internal break-down.



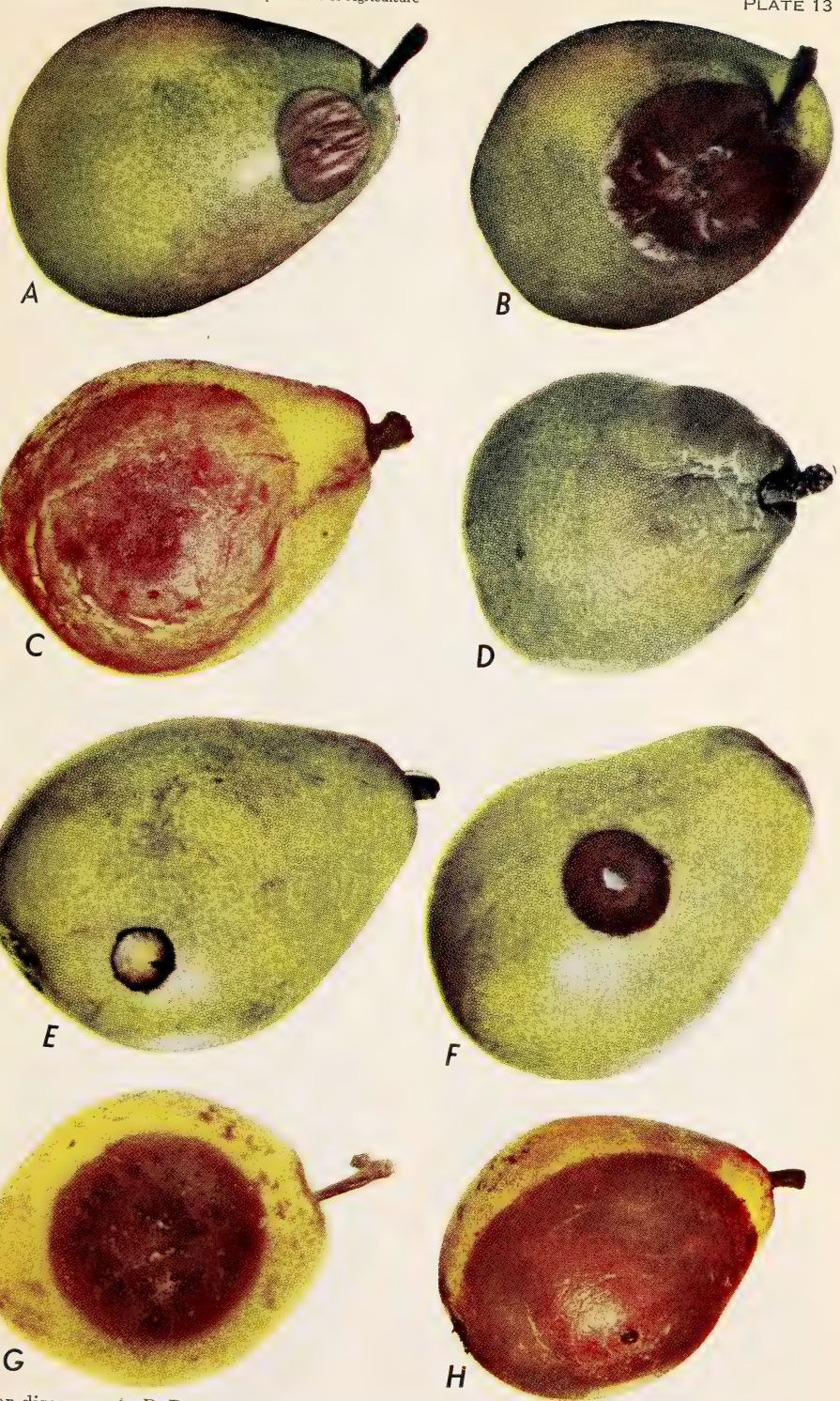
Apple injuries and diseases: *A*, Transit bruise; *B*, bruise produced by constant pressure (not freezing injury); *C*, fractured bruise; *D*, slight freezing injury, in primary vascular bundles; *E*, extensive freezing injury; *F*, water core not visible externally; *G*, *H*, water core visible externally.



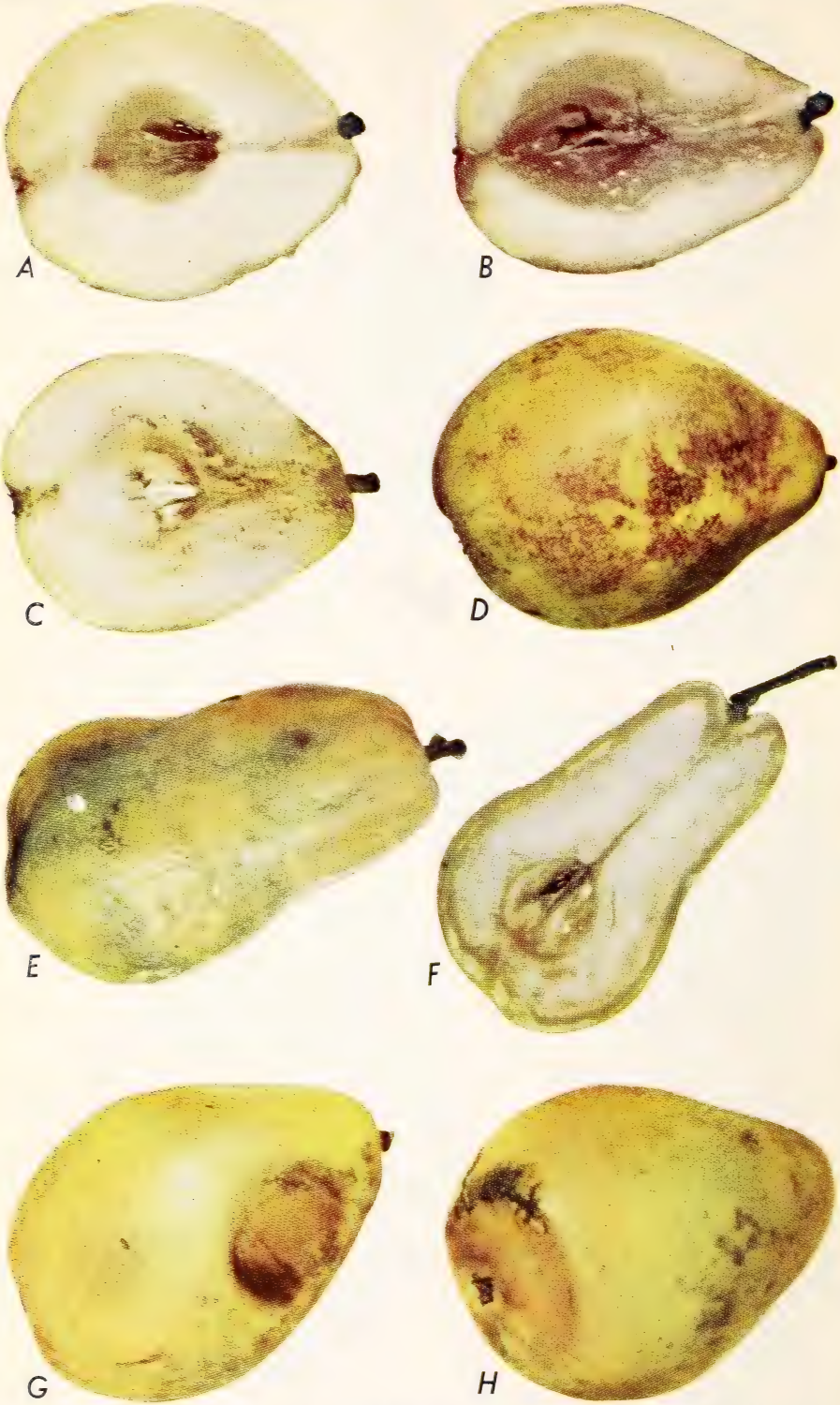
Diseases and injuries of pear and quince: *A*, Scab; *B*, *C*, black spot; *D*, pear leaf blister mite injury; *E*, copper injury; *F*, ammonia injury; *G*, *H*, sodium chloro-2-phenylphenate injury.



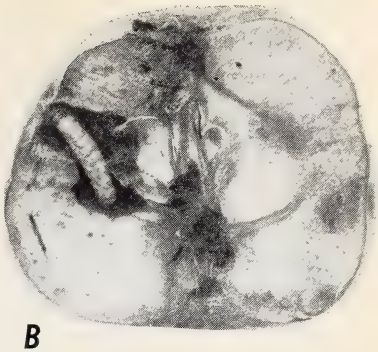
Pear diseases: *A*, *B*, Black end; *C*, *D*, boron-deficiency pitting; *E*, *F*, corky spot; *G*, *H*, stony pit.

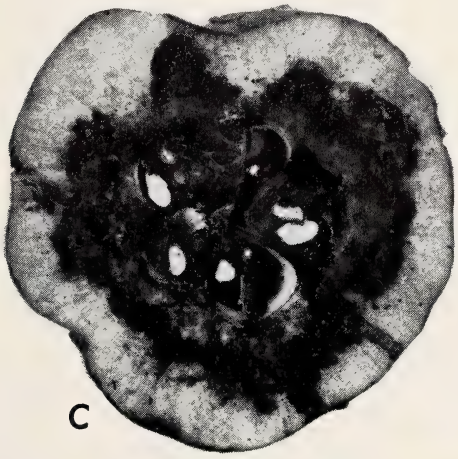


Pear diseases: *A*, *B*, Blue mold rot; *C*, *D*, gray mold rot; *E*, bull's-eye rot; *F*, side rot; *G*, brown rot; *H*, rhizopus rot.



Pear diseases and injuries: *A*, *B*, Core break-down; *C*, old-age break-down; *D*, Anjou scald; *E*, *F*, freezing injury; *G*, *H*, transit bruising.





A, Apple-maggot-injured apple; *B*, codling-moth-worm-injured apple; *C*, quince severely infested by oriental fruit moth; *D*, apple injured by red-banded leaf roller; *E*, apple showing fall feeding punctures of plum curculio.

Apples showing typical scarring by plum curculio.

Apples injured by fruit tree leaf roller.

Basket of apples affected with gray mold rot, which probably started from one infected fruit.